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THE CEREAL RUSTS AND THEIR CONTROL*

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Because of their depredations on man's most time-honored and vitally important food crops, the rusts probably are among the most widely known and most dreaded of all the diseases of wheat, oats, barley and rye. Literature, both sacred and profane, has not a little to say about rust, and many were the supplications and ceremonies uttered and performed to enlist this god or that against the ravages of this evil spirit, this handmaid of famine and pestilence. With the invention and subsequent improvement of the microscope in the seventeenth century, it was finally discovered in the eighteenth century that rust was caused by minute living organisms. Finally, in 1864-1865, a distinguished Bavarian student of the fungi, Anton de Bary, unraveled the complicated life history of stem rust. Thus was established, once and for all, the parasitic nature of the rust fungus.

It is not my purpose here, nor is it necessary, to give a detailed account of the life history of each of the several rust organisms, or of any one of them in particular. It is enough to state that, in the main, they are essentially similar in their life cycles. Each, excepting *Puccinia glumarum* (Schm.) Eriks. and Henn., the stripe-rust organism, has its alternate host and one may yet be found for this single exception. Each produces its specific type of urediniospore, followed in due course by characteristic teliospores; each is characterized by physiologic specialization; and each is incapable of attacking any alternate host other than its own.

Those rusts with which we are here chiefly concerned are, in the order of their economic importance, the stem rusts of wheat, oats, and rye; leaf rust of wheat; crown rust of oats; stripe rust of wheat, barley, and rye; the leaf rusts of rye and barley; and corn rust. There is also the rust of sorghum, but for the present we shall leave its consideration out of this account.

Some of these rusts, notably *Puccinia graminis* Pers., *P. glumarum,* and *P. coronata* Corda, occur on a considerable number of wild grasses. The present known number of such hosts for *P. graminis* is between 90 and 100; *P. glumarum* is known to occur on 61 cultivated and wild grasses; and *P. coronata avenae* attacks 8 species of Avena and numerous species in 15 other genera of the Gramineae. These several grass hosts figure importantly as factors in the epiphytology of their specific rusts. Especially is this true in the case of stem rust when susceptible grasses are a part of the barberry environment. Perennial grasses subject to stripe rust no doubt function im-

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portantly in the winter and summer survival of the rust organism in its vegetative condition.

Stem rust in North America is virtually coextensive with its several hosts. Its greatest economic importance obtains in the Prairie Provinces and the States of the Upper Mississippi Valley, but its ravages have been felt in every part of the continent where cereals are grown. It is most abundant and persistent in those States and Provinces where barberry abounds and where its wild-grass hosts are abundant and contiguous to barberry bushes. Like all rusts, it is sensitive to weather conditions, especially temperature, light and humidity. It does not ordinarily hibernate in the uredinial stage north of the Gulf States and along the Pacific Slope.

Leaf rust of wheat, *Puccinia triticina* Eriks., occurs in North America wherever wheat is grown. Although it is parasitic on Thalictrum species, it does not depend on its alternate host for propagation and spread. Apparently it overwinters readily wherever conditions favor the easy survival of winter wheat. Outside of the genus Triticum, it is known to occur on a few species of Aegilops. Under certain conditions, certain other cultivated and wild grasses may become infected. Ordinarily, it does not parasitize other gramineae, though it has been reported on barley.

Crown rust, *Puccinia coronata,* is widely distributed throughout the world. In the United States, it is virtually coextensive with oat culture and the distribution of numerous wild grasses. In those regions of North America where the winters are mild enough to insure the successful culture of winter oats, the crown-rust organism hibernates. In regions farther north it develops copiously on its alternate hosts.

Included among the alternate hosts of crown rust are many species of Rhamnus and members of two other genera of the family Rhamnaceae. Two genera of the family Elaeagnaceae also contain species which act as alternate hosts of this rust. In the Northern States, *Rhamnus cathartica, R. alnifolia,* and *R. lanceolata* are its most common aecial hosts and they play a very important part in the recurrent initiation and spread of crown rust.

The leaf rust of barley, *Puccinia anomala* Rostr., is not so prevalent as the other cereal rusts. In those areas devoted to spring barley, it usually occurs as a mild infection if it occurs at all. Occasionally it develops locally and destructively on winter barley in the Southeastern States. It occurs naturally on different species of Hordeum and, under certain favorable conditions, other cereals and wild grasses may be infected. The aecial stage of this rust occurs on two species of the genus Ornithogalum.

The leaf rust of rye, *Puccinia dispersa* Eriks. and Henn., is widely distributed. Conditions favorable to its development parallel closely those most favorable to leaf rust of wheat. Its host range is confined to the genus Secale and the alternate host Anchusa of which latter three species have been found susceptible.

Stripe rust, *Puccinia glumarum* was first collected in the United States near Seattle, Wash., in 1892. It was not then identified as such, and, indeed, its discovery and correct identification in North America were not made until May, 1915, when it was collected in Arizona by Dr. Kølpin Ravn of Denmark.

In North America, this rust is confined to the Pacific and Intermountain Provinces and States. It is parasitic on wheat, spelt, emmer, barley, rye, and more than 60 cultivated and wild grasses. If it has an alternate host, the fact remains yet to be discovered. Its ability to survive our rigorous winters and the long dry summers of the arid West insures its survival, probably as dormant mycelium within the tissues of certain perennial hosts and winter cereals.

Corn rust, *Puccinia sorghi* Schw., does not occur, as the name would seem to indicate, on sorghum. The fungus was named by Schweinitz who mistook the infected specimen submitted to him. He inferred that it was sorghum rather than maize.

This rust occurs on the genus Oxalis, its alternate or aecial host, and passes readily from this host to *Zea mays*. It is pathogenic also on Teosinte and Euchloena.

Economic Importance

The cereal rusts as a whole have long been recognized to be the most generally destructive and widespread of our grain-crop diseases. Stem rust and orange leaf rust, in particular, not infrequently cause enormous losses which affect not only wheat farming but all related industries as well. In 1916, stem rust alone is said to have caused a loss to the farmers of the spring-wheat States and Provinces approximating 300,000,000 bushels of wheat. In 1927 this rust is estimated as having destroyed over 33,000,000 bushels of wheat in 16 of the 48 states of the United States.

Leaf rust, long thought to be of relatively minor importance, is now known to be second only to stem rust. Probably, in occasional years, it is more destructive than stem rust, though ordinarily its real effect on the host is apt to be overlooked. In 1927, an epidemic year, loss from this rust in 19 states was estimated at 28,500,000 bushels, manifest for the most part in reduced yield rather than in markedly inferior bushel weight and quality.

The leaf rusts of barley and rye, while of some economic importance, hardly rank with the stem rust of these cereals. Fall-sown barley and rye occasionally are affected seriously but, usually, only locally.

From the standpoint of its economic importance, probably no disease of oats in the United States causes so great a reduction in yield as does crown rust. The severity of infection varies considerably from year to year and in different sections of the country. There seldom is a year when it is not seriously destructive in the Southern States, where it hibernates abundantly on fall-sown oats.

In 1927, the estimated loss caused by crown rust in the United States was 56,987,000 bushels or 4.1 per cent of the crop. During the 10-year period, 1918-1927, crown rust caused greater damage than did stem rust in five out of the ten years. Much of this recurrent loss caused by crown rust could be permanently prevented through the eradication of the buckthorn and the adoption of rust-resistant hybrids. Considerable progress in developing such hybrids already has been made.

Stripe rust in America has thus far caused little damage to wheat except in certain restricted areas. The most destructive outbreak yet recorded

occurred last summer in the Flathead Valley, western Montana, where certain fields of winter wheat showed an infection severity well in excess of 85 per cent.

We have no accurate data concerning the effect of *Puccinia sorghi* on corn. Locally, it may have considerable economic importance, sometimes being so destructive as appreciably to reduce ear development of the most susceptible varieties. According to United States Department of Agriculture estimates, this rust caused a total yield reduction of 25,124,000 bushels for the nine-year period 1919 to 1927.

Epiphytology

In many respects the cereal rusts are much alike from the standpoint of factors affecting their epiphytology. They all require high relative humidity and relatively low summer-morning temperatures for the germination of their urediniospores. Sunlight also may be an important factor. We already know it is so for stem rust. With the exception of *Puccinia sorghi,* they all overwinter quite generally in the United States, either in the form of dormant mycelium or as urediniospores, or both. Some of them, notably the leaf rusts of wheat and rye and crown rust of oats and related grasses, hibernate probably much farther north and much more generally than does stem rust. There is an ever-accumulating mass of observational evidence, however, to show that stem rust may overwinter sparingly as far north as Montana and Wisconsin, particularly during winters of heavy and continuous snow cover.

With the exception of *Puccinia graminis, P. triticina,* and probably *P. sorghi,* the cereal-rust fungi in North America depend but little, if any, on their alternate hosts for their propagation and spread. There is some evidence to show that the progress of stem rust, orange leaf rust, and crown rust is from the south, but it is plainly evident that the south-to-north drift of urediniospores does not fully meet all the conditions incident to an epiphytotic. Especially is this true in the case of the leaf rusts of wheat and rye which hibernate rather generally where and when the infected leaves of their respective hosts survive the rigors of winter. So far as concerns *Puccinia coronata* and *P. graminis,* it must be admitted that there is unassailable evidence to show that epiphytotics of these rusts are in large measure dependent on the still too general presence of their aecial hosts. Infected barberry bushes, and to a less degree rusted buckthorn, aided by continental storms, play a very definite part in initiating and augmenting epiphytotics over more than merely local areas.

Physiologic Specialization

Probably no discovery in the realm of plant pathology has had deeper significance or will prove more far-reaching in its agronomic and pathologic consequences than has the discovery of physiologic specialization in the rusts.

Until 1896, this specialization had passed unnoticed or at least unrecorded. In that year, two Swedish botanists, Eriksson and Henning, announced their discovery. They demonstrated that the stem-rust fungus, *Puccinia graminis,* peculiar to wheat and barley and closely related grasses, was incapable of attacking oats, rye, or timothy. Likewise, they found that the stem rust of rye, or that of oats or of timothy, did not infect wheat or

barley or any other than its own peculiar host; and this, notwithstanding the fact that, morphologically, these several strains were all alike. They differed physiologically; that is to say, they differed in idiosyncrasies as to host congeniality.

In 1916, Stakman and Piemeisel discovered that this physiologic discrimination extended even to differentiation within a given physiologic "variety" of *P. graminis*. They found that *P. graminis tritici*, the variety peculiar to wheat and barley, in reality comprised a number of "physiologic forms" each differing more or less from the others in its infection capabilities and behavior on a given set of differential species, subspecies, and varieties of triticum.

This discovery opened the way for the further development of our knowledge of physiologic specialization in the rust fungi by Stakman and his coworkers, by such Canadian workers as Bailey, Newton, and Johnson, and by other students in the States, notably Mains, Parker, and Melchers. As a result of their researches we now recognize 62 physiologic forms of *P. graminis tritici*, 6 of *P. graminis avenae* and 14 of *P. graminis secalis*. Stakman and Levine also have discovered special forms of physiologic varieties of *P. graminis* on Poa and Agrostis, namely, *P. graminis poae* and *P. graminis agrostidis*. We now recognize 12 physiologic forms of orange leaf rust, at least 2 forms of the leaf rust of barley, a yet undetermined number for the leaf rust of rye, and, according to Stakman, Christensen, and Brewbaker, 7 physiologic forms of *Puccinia sorghi*, the corn-rust fungus. There are now 9 known physiologic forms of *P. coronata avenae*, the special physiologic variety of crown rust peculiar to oats. One of these is virulent on all known species and varieties of Avena. *Puccinia glumarum* in North America differentiates into at least 2 physiologic forms, and in the British Isles there apparently is a third form, if there are not others.

It is not yet clearly known how all this physiologic specialization has come about. The epochal discovery by Craigie of the phenomena fundamental to the origin and development of aeciospores may hold the answer. Possibly the way lies through mutation. Who knows? In any event, the matter is of tremendous importance to the plant breeder, the agronomist, and the plant pathologist. It is bound to exert great influence on our control of the cereal rusts, no matter by what means this control may be sought, and it will profoundly affect, indeed it already is affecting, our concept of plant pathogenes and their behavior.

Control of the Rusts

From the foregoing facts relative to the distribution, the life history, the factors affecting epiphytotics, and the phenomenon of physiologic specialization and its possible origin, it will be seen how very intimate and, at the same time, intricate, is the relation between these several aspects of the rust problem and the adequate control of any single rust. A first essential to the attainment of this most important end point is the closest sort of intelligent coöperation between agronomists and geneticists on the one hand and the plant pathologists on the other.

The development of disease-resistant hybrids of the several cereals is a slow, tedious process fraught with many difficulties and requiring not only

sound knowledge of the pathology of cereals but acquaintance with the agronomic and genetic aspects of the problem. It is not enough merely to breed for hybrid strains of wheat highly resistant to or immune from stem rust alone. We must endeavor to combine in such hybrid strains a fixed resistance to leaf rust, to bunt and loose smut, to scab and black chaff and foot rot. The same principle applies in the case of oats. Merely to breed and select for resistance to oat smuts is to go only part way. And so with all the cereals. Added to disease resistance we must continually have an eye to improving the yield, the quality, resistance to lodging and, in the winter cereals, resistance to the factors involved in winter killing.

With all these requirements in view, the Office of Cereal Crops and Diseases of the United States Department of Agriculture is coöperating with many State agricultural experiment stations to the end that considerable progress already has been made in the direction of producing promising disease-resistant varieties of wheat, oats, barley, rye, corn, and other cereal crops.

At University Farm, St. Paul, a cereal pathology garden has been established in which all promising wheat hybrids are subjected to rusts, smuts, scab, foot rot, etc. If any can run the gamut of such a test they are saved for further proof of their fitness. Similar nurseries are being established in other major crop areas with the same objective in view. We realize that the adoption of such a procedure may prolong the journey to our goal but there seems to be no short cut across lots.

Our only business as a working coöperative organization is crop improvement. If we are to succeed we must take into account all aspects of the great problem. With the rust resistance of selections from the double cross, (Marquis × Iumillo) × (Marquis × Kanred), we must endeavor to combine through further crossing and selection real resistance to the smuts, to scab, and to the major foot rots. We must work for like resistance in the soft red winter wheats of the East and South and in the hard red winter wheats of the Southwest. Likewise, in our oat-improvement research we must seek out those hybrids in which, through crossing and double-crossing and back-crossing, we have combined with resistance to the rusts resistance to the smuts and other diseases of major importance. This type of research is under way and some progress has been made toward the attainment of the coveted goal.

The problem of disease control is too stupendous to be solved by the worker within any one restricted field. Dusting with whatever fungicide is expensive and still far from practical. At best it can be little more than a temporary means to an end. What may yet come of it remains to be seen. Eradication of the barberry and buckthorn unquestionably will be valuable and permanently helpful but it will not prevent the ravages of stem rust and crown rust, traceable to urediniospores of southern origin. We must all pool our research facilities, our thought, our enthusiasm, our uttermost resources to the solution of the great problem. On both sides of the boundary line we are spending large sums of money wisely and well to this end. On barberry eradication alone the United States has spent during the last eleven years approximately 3¼ million dollars. We can well afford it when we

recall that in a rust year like that of 1916, stem rust caused a loss of nearly $200,000,000 to the farmers of Minnesota, North Dakota, and South Dakota. We must continue to spend money and time and labor on barberry eradication. More than 17,580,000 bushes, sprouts, and seedlings have been destroyed. How many more yet remain to be destroyed, nobody knows. They are legion, in Ohio, in Michigan, throughout the barberry-eradication area and in Ontario. We need to combine our resources toward the complete wiping out of a common enemy. We must do this if we are to save to our farmers the heritage of their toil, their fertile lands, their God-given opportunity to be prosperous builders of a great international agriculture.

BOOK REVIEW

THE FUNGI OF MANITOBA, by Bisby, G. R., Buller, A. H. Reginald; and Dearness, John, with a preface by E. J. Butler, F.R.S., Director of the Imperial Bureau of Mycology. 8° pp. 1-194. 1929. (Longmans, Green and Co., London, New York, Toronto, 7/6 net.)

This is indeed a most happy association of authors, all three of them authorities on the subject and pioneers all in the study of fungi of the Dominion, especially that nestor of Canadian Mycology: John Dearness. It is, moreover, the first (I hope of an equally interesting series to come,) of books on a subject which has been deplorably neglected, by way of publication, in the Dominion. The authors, as might be expected, have acquitted themselves remarkably well, and a handy little volume, capable of great inspiration to others similarly inclined, at very reasonable cost *, well-bound, clearly printed, with a wealth of information, may now find a place on the shelves of the library of many a student engaged in the pursuit of knowledge regarding these plants in Canada and abroad.

It is a wonder how we could have possibly gone on so long without a more exact knowledge of the kind and distribution of fungi of Canada, and yet, notwithstanding, have made the gratifying progress in plant pathology, and in the study of parasitic fungi of general economic importance in the country. This fundamental need of a thorough knowledge of the destructive fungus parasites of a country is well brought out by a sentence in the preface by that distinguished and accomplished director of the Imperial Bureau of Mycology: "Still greater is the need of the applied mycologist or plant pathologist for detailed information regarding the fungus flora of the region in which he works, and, to a certain extent also, of regions from which dangerous fungi might be introduced."

The contents are divided into nineteen sections, including one on lichens of Manitoba, contributed by Kirk Scott Wright, every one of which contains valuable and often original information and instructive annotations concerning individual fungi and their characteristics which make the treatise a valuable text-book in itself. The collections include forty-five new species and two new varieties, and for Manitoba the large number of—but get the book and see for yourself. I can cordially and unreservedly commend it.

H. T. G.

*Copies of the book may be obtained in Canada from Prof. V. W. Jackson, Manitoba Agricultural College, Manitoba.

THE EFFECT OF CHANGES IN HUMAN RELATIONS ON BARGAINING POWER*

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That the law of supply and demand no longer works is an assertion frequently heard in modern times. The statement is based on the changing position of the individual as a bargainer in the market. Unquestionably, the position of the individual as a bargainer has materially changed from what it was when Adam Smith set forth his doctrines in his epoch-making "Wealth of Nations" in 1776.

Smith's ideas have had a profound effect upon economic doctrine in every generation since his time. His philosophy was based upon the assumption that the individual would follow his self-interest and do the things that would result in the best for him and that this would result in the best for everyone. Free competition was assumed to be essential in the economic order. Back of all this was the assumption that man's actions were subject to natural laws that were as immutable as the laws of the Medes and the Persians.

The result was a set of economic doctrines stressing individualism. The individual needed no help. He should be left to his own devices and consequently would work out his salvation along the best lines. The best for the nation was the sum total of the best for the individuals composing the nation and national well-being was to be secured by giving individuals free rein. The attitude of the government should be one of *laissez-faire* — maintain fair play and let free competition and self-interest have full sway. These individuals would of necessity follow natural laws resulting in the attainment of the best.

Under these doctrines market price resulted from the free interplay of supply and demand in the market place. Values were determined, to quote Smith, "by the higgling and bargaining of the market according to that sort of rough equality which, though not exact, is sufficient for carrying on the business of common life."‡ This assumed approximate equality of bargaining power on the part of buyer and seller. Both would know the state of the market and could compete on an equal footing. This probably approximated the actual situation in the time of Adam Smith.

Smith's doctrines have been handed down to us through Ricardo, Mill, Marshall and Taussig in much their original form. Consequently, we find many people still adhering quite closely to the doctrines pertaining to market price as set forth by Smith. Such adherence is not to be deplored but at the same time, one must recognize the changed and changing conditions which make modification of these doctrines desirable and necessary.

Smith's fundamental premises of self interest, free competition, *laissez-faire,* and a natural order have long ago been proved untenable but his statement of the determination of market price contains the framework of

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‡Adam Smith—"Wealth of Nations", Chapter V.

the truth as we see it today. Market price is still the result of the "higgling and bargaining of the market" according to a sort of rough equality. Those who have been the unfortunate victims of this higgling and bargaining sometimes stress the "rough" phases of the market rather than the "equality" of buyer and seller in it.

Students of market price in the modern market agree with Smith's statement but they no longer agree with him in assuming that buyer and seller have equal knowledge or equal bargaining ability. In fact, unequal bargaining power of buyer and seller is more frequently the essence of the modern market. If it is assumed that equal bargaining power is essential for the operation of the so-called law of supply and demand then the assertion that it no longer works is a valid one.

However, is this the real interpretation of the law of supply and demand? In reality, it is not a law but is merely a statement of fact, which is that the quantity demanded will equal the quantity supplied at a given price in any market. In other words it is a truism—the quantity taken in the market equals the quantity supplied in that market. This makes no reference to the relative bargaining ability of the buyers and sellers in the market. In fact, it assumes whatever situation that may exist.

On the other hand, the facts back of the common statement concerning the present working of supply and demand, cannot be discussed so easily. Changes have occurred that must be reckoned with and the unequal bargaining abilities of buyers and sellers are facts of modern economic life that must be taken into consideration in any appraisal of modern market-making forces.

In the first place, the attitude of the public, as expressed through government, toward the economic problems of the individual has changed fundamentally since the time of Adam Smith. In his time, the doctrine of "let the buyer beware" was orthodox business. At present, the buyer as well as the seller is safeguarded on every hand by governmental inspection and regulation. Food products are inspected, packages must meet certain requirements, adulteration is prohibited and in many other ways it is recognized that buyer and seller are not on an equal footing when left alone. The power of the state is injected to more nearly equalize the positions of buyer and seller.

Similar changes have occurred in the labor market and the laborer is now protected in the sale of his time. Minimum wage legislation, workmen's compensation insurance, employers' liability and many other devices help to equalize the bargaining ability of the laborer.

In the field of agricultural products, better bargaining ability is insured buyer or seller by grading and classification of products, by provision for standard containers and by governmental dissemination of market news and price-determining information.

In many ways, governments have recognized that either the buyer or the seller may be a weak bargainer and an attempt has been made to either protect him against his own weakness or to strengthen his position.

Not only has the government helped strengthen the bargaining ability of the weak but in many instances steps have been taken to curb the strength

of the strong. Monopoly power that would result in practices unfair to the majority of the people have been frowned upon and frequently curbed by legislative enactment or by decree of governmental regulatory bodies.

The philosophy of modern government is one of social welfare in which active participation by the government is essential. It is no longer assumed that the individual is the best judge of his own welfare or that he can best further his welfare if left alone and unaided.

Another doctrine that has gone into the discard is that of a natural order which is inevitable. Natural law which is unchangeable is recognized but it is also recognized that there are ways in which these natural laws may be induced to work that are beneficial to man. The old philosophy of Adam Smith and his followers smacked of materialism. In other words, man was the creature of his environment and there was little if anything that man could do about it. Each individual, working alone, could adapt himself to this environment and group action was not essential. This is the logical conclusion one reaches from Smith's premises, but in justice to him it should be stated that he did not carry his individualism to this extreme. The canny Scotchman was too pragmatic for this and readily recognized the advantage of division of labor and similar group activities.. However, his idea of group action stopped far short of that which is prevalent today. Coöperative endeavor and governmental action in the social interest were contrary to his doctrines. They are the essence of modern economic life.

It is now readily recognized that man can exert considerable influence over his environment and in part, at least, order it to suit his needs. Natural laws are made to work for man. So we have the efforts of the plant and animal breeders, of the chemist and the physicist, of the engineer and the economist, all endeavoring to divert natural phenomena into channels beneficial to mankind.

This view of the relation of man to his environment opens up entirely new fields from those contemplated by Adam Smith. Since man can influence his environment it follows that he can exert greater influence by coöperating with his fellowmen in his activities. Two become better than one. The old individualism of the materialistic philosophy of Adam Smith is replaced by a social philosophy that contemplates group action in the social interest and the adaptation of environment to the needs of men.

Under this new philosophy, which is in reality not new, but is that which has dominated our lives during recent years, the sphere of governmental activity is infinitely enlarged. The government is the agency of the large social group and is one of the most important agencies furthering social welfare. The government furthers regulation, inspection, standardization, investigation and other activities having for their purposes progress and improvement in products that will increase economic well-being and social welfare.

A logical outcome of this change in philosophy and in the attitude of governments is the change in the relative importance of the individual as compared to the group. The individual as an economic and social force has tended to fade into the background and has been replaced by the group. Whenever something is desired in modern life an individual rarely asks

for it. Rather the individual seeks other individuals with similar desires and forms a group with like interests who present a concerted demand for the thing or things wanted. The day of individual activity or action has passed. Action is taken by groups on behalf of groups and in the interest of groups. Governments give heed to groups where the demands of individuals pass unnoticed. It is a day of group activity. It has reached the point where it is frequently said that we now have government by groups and there is a good deal of truth in it.

These groups are constantly asking for things which they believe will be to their economic interest. Higher tariffs or lower tariffs as the case may be, lower taxes, preferential freight rates and many other advantages, or supposed advantages, are requested and oftentimes demanded. It does not follow that while Adam Smith held the judgment of the individual to be infallible, those who contend that the group has displaced the individual hold that the judgment of the group is infallible. Such conclusions seem on certain occasions to have been reached by people high in office with regard to the tariff and other matters. The fact that a large group wishes a certain thing seems to be logical proof to them that it should be given them. I am sure that no economist would admit the infallibility of the judgment of the group or the fallibility of his own judgment to this extent. However, right or wrong, groups are making requests and demands and most of the demands that must be dealt with in modern life are from groups.

All of this is matter of every day observation. We observe these groups in action and see on every hand the effects of group activity in the social interest. But group action and group consciousness have not permeated all of our lives, particularly our economic relations.

Back to the law of supply and demand: complaint is frequently registered because it does not operate as it formerly did. In former days, individual met individual in the market place, wherever it might be, and the higgling and bargaining was between individuals. Many of us still insist upon going into the markets of the world as individuals and we protest at the change when we find that others are coming there not as individuals but as groups. Bargaining power has been pooled and our own individual efforts seem puny and dwarfed beside the combined bargaining power of these groups.

Concentration of control is the outstanding characteristic of modern business. Opposition to this concentration has been swept aside and each year has seen greater and greater concentration of control. This has increased the bargaining power of these groups in the market and has placed the individual at increasing disadvantages as a bargainer.

The types of business most frequently thought of in this concentration include banking, transportation and manufacturing. However, concentration has not been confined to these fields. The chain store and the Independent Grocers' Alliance are examples of concentration of bargaining ability within the retail field. In agriculture the growth of coöperative buying and selling is evidence of the same movement. The Canadian Wheat Pool is an outstanding example of concentration of control and the resultant increase in bargaining ability.

Agricultural coöperation is growing by leaps and bounds and each year finds new faces among the agricultural coöperatives that can now be classed as big business. This is as it should be. By organizing and operating these coöperatives, farmers are helping themselves to a rightful place as bargainers in the markets of the world. To deny farmers this right to organize and operate their coöperatives would be to relegate them to the individualism of generations ago. It is to the credit of farmers that they have kept pace with the times, at least in part, and are prepared to meet concerted bargaining power with concerted bargaining power.

Farmers and business men have not been the only groups organizing for the purpose of more effective bargaining power. Early in the present era the laborer found himself a woefully weak bargainer. He must sell his time or he loses it forever. Furthermore, if he does not sell it he may starve. Taken alone the individual laborer is one of the weakest bargainers in any market. However, by organizing and pooling their efforts laborers have been able to present a united front with concerted bargaining power. Today, organized labor is one of the most effective bargainers of modern economic life. Few laborers dream of going back to the old days of no organization and unlimited competition for jobs. The advantages of collective bargaining are so numerous and so great that they would be given up very reluctantly, if at all.

This change in bargaining ability is the answer to the assertion that the law of supply and demand does not operate as in former years. It does not operate with individual competing with individual as before. Group bargaining differs from individual bargaining. Changed and changing conditions have brought new problems and new facts that alter situations. The remedy is not in going back to old conditions of individual bargaining but in recognizing the causes of the changes and adapting ourselves to them. Group activity has come to stay and group action in the market is a thing that will endure. The individual's salvation is along one of two lines. He can either depend upon the government to aid him to maintain his position as a bargainer and to protect his interests, or he can associate himself with others and by collective action maintain effective bargaining power in the markets. The latter method is the more commendable since it involves self help and initiative on the part of the individual.

The old truism of the law of supply and demand still holds but back of supply and back of demand are forces that are becoming increasingly powerful with each passing year. This is a challenge and an opportunity to all who are endeavoring to increase economic well being and social welfare. The greater the concentration of control the fewer the people who must become convinced of the desirability of changes in methods and policies.

For example, improvements in banking policies may be secured with greater ease in a country where the banks are all in one system, or in a few systems, than where there are many small independent banks. In the first case, all that is needed is to convince the leaders of the system or systems. In the latter case each individual banker presents a separate problem. Progress under the first described conditions can be made more easily and with less effort than in the second instance.

Similarly, improvements in the production and marketing of farm products can be made much more easily when farmers are organized into groups and act as groups. Organized effort among farmers is limited by the nature of farming but even with those handicaps, improvements among farmers are much more easily and readily made when they are organized.

The furtherance of agricultural improvements through organizations of farmers has much to commend it and at the same time requires a higher degree of courage than where improvements go to farmers individually. A mistaken policy advocated to a group and adopted by them is magnified by the size of the group. Consequently, in working through groups double caution, to be sure that results and recommendations are unquestionable, is essential.

And so the doctrines of Adam Smith, while well suited to his time, are not well suited to the present. *Laissez-faire,* free competition and self interest are doctrines of the past. In their stead we have governmental activity and participation, regulated competition and even monopoly, and the dominance of the social interest. With these changing conditions, the factors of the market are no longer the same. Instead of the meeting of individuals with their respective bargaining powers, there is the meeting of collective bargaining powers. As ever, the one in the stronger position has the advantage. Group activity is essential in this whether the commodity bargained for is wheat, coal, or education.

As we look to the future, there is no evidence of a let-up in this battle of organized demands. The forces urging organization seem to gather momentum as they go and it seems inevitable that our economic and social life of the future will be a matter of organized activity even beyond what we have today. This is not necessarily a thing to regret but it is a movement of which we should be fully aware, and consequently take full opportunity of in securing desirable ends.

One problem that grows out of the tendency to concentrate control is the future of the independent operator who has been so prominent a factor in this past. Associated with this problem is that of the independent action of the farmer who has marketed the product he has produced. Are values to be lost in the passing of these two instances of individual action that are not to be compensated for in some other way?

In the first place, there is no certainty that the independent retailer or other operator or the independence of the farmer will be lost. Their much touted independence has been more imaginary than real so even if lost the loss would not be great. The concentration of bargaining power does not necessarily eliminate the individual entrepreneurs. Collective bargaining power is attained by pooling efforts along certain lines. For example, grocers in the Independent Grocers' Alliance have pooled their purchases. None of their other activities have been pooled and there appears to be little need of pooling them. The liberty of action of the individual has been influenced but little.

In the same way farmers have pooled their sales through coöperative marketing. They retain their individual rights to plan their production as

they see fit and in many ways they are fully as independent as, and may be more independent than, they were before they pooled their marketings. Their greater prosperity, if any, may give greater economic independence.

The compensating factor for any loss in individual action seems to be through the widespread diffusion of ownership of the common stock of industries by the rank and file of the population. The period since the World War has seen more people coming into the possession of stocks and bonds than ever before. It seems safe to assume that, while control of industries may be concentrated in the hands of the capable few, yet the ownership will remain widely diffused. This diffusion of ownership suggests itself as an antidote to any harmful effects of the movement to concentrate control.

From the standpoint of the scientist, these days of organization, of collective bargaining power and of group action offer golden opportunities. These conditions provide the fullest opportunity for the appreciation of scientific research and an organized society offers the greatest opportunity to secure the widespread adoption of the results of scientific research. Any administrator of an institution conducting scientific research will testify that there never was a time when business was more interested in the results of scientific research or more ready to hire the scientist who gives promise of developing results of value to the business. The number of men leaving the strictly scientific field to engage in scientific work for business concerns is constantly increasing. This is the way the commercial world has of paying tribute to the value of science to it. Also, this emphasizes the opportunities of science to be useful to mankind.

THE IMPROVEMENT OF WESTERN RYE GRASS, *Agropyron tenerum*, Vasey. *

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Western rye grass, more correctly called slender wheat grass‡, is indigenous to the northern Great Plains region of North America. While it is not of primary importance compared with other cultivated grasses, it is nevertheless of great economic value in that area to which it is naturally adapted, namely the prairie and park belt sections of Western Canada and the adjacent states of the United States. It has the distinction of being the only perennial cultivated grass of importance which is native to America, all other species having been introduced from Europe.

Western rye grass was first cultivated in 1885 by a Mr. McIvor of Virden, Manitoba. About the same time it was tested by Dr. S. A. Bedford, Superintendent of the Dominion Experimental Farm at Brandon. Dr. Bedford was much impressed with the possibilities of the grass as a cultivated crop for Western conditions and had the seed multiplied and distributed. Since that time his judgment has been amply justified, as it still is regarded unanimously as the best cultivated hay crop for general use in the three prairie provinces.

Western rye grass is a densely tufted perennial, without rootstocks, which grows from 18 to 40 inches high. The leaf blades are nearly smooth, three to ten inches long, flat or rolled. Numerous erect fertile and sterile shoots are produced. The spikes are slender, two to seven inches long; the three to five flowered spikelets are long and narrow and closely appressed to the main stem; the glumes are sharp pointed, not awned; and the lemmas are tipped with a stiff awn or awn point one-eighth to one-fourth of an inch long or awnless. As the plants approach maturity they become straw colored, the head being the first to turn yellow.

Sampson (*9*) states that "about sixty species of wheat grasses have been described, approximately thirty-five of which occur in the United States. About twenty species occur in the Western States". Of these *A. tenerum* is the most widely distributed and the only one to be brought under cultivation. Nearly all of the species are valuable as forage plants, and in many localities on the Western ranges, stockmen depend very largely upon the herbage of wheat grasses to grow and fatten their stock. In Western Canada the most important species are western rye grass, *A. tenerum*, and western wheat grass, *A. Smithii*. The latter is widely distributed and forms an important part of the natural herbage on prairie soils, but its poor seeding habits have prevented its use as a cultivated crop.

Western rye grass possesses just those characters which are necessary under the soil and climatic conditions of Wetern Canada to make it of great

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‡The correct name for this species is "slender wheat grass". It was erroneously called "western rye grass" when it was first grown under cultivation and the name appears to be firmly established in Canada.

economic value as a cultivated crop. It is winter-hardy, drought resistant, productive, an excellent seed producer and the seed is of good quality. It is also fairly tolerant of alkali salts, an important advantage under semi-arid conditions. In feeding quality it ranks high being one of the choicest of grass feeds for all classes of stock.

In preparing this paper the writer has endeavored to give the present status of western rye grass breeding and to outline what has been accomplished to date by plant breeders toward the improvement of this crop. In doing so he has had the generous coöperation of Dominion Experimental Farm investigators who are engaged in this line of work.

Mode of Pollination

Slender wheat grass differs from all other cultivated grasses in that it is normally self-fertilized. This discovery was made by Malte (*5*) in 1913 when he was studying the systematic relationship of numerous wild forms growing in the neighborhood of Edmonton, Alberta. A careful examination of the flowering parts with the aid of a lens at the time of pollination disclosed several features which indicated very clearly that the florets were naturally adapted for self-fertilization. The stamens did not protrude from between the glumes as is normally the case in grasses, but remained inside and exploded when still far down in the flower, sprinkling the pollen over the stigmas and the inside of the flowering glumes. Malte concluded that "the chances of the pistil of a flower being fertilized by pollen, either from another flower on the same plant or from a flower on another plant, were extremely small".

In order to further test the validity of his hypothesis with respect to the mode of pollination of western rye grass, Malte selected, in the fall of 1913, nine plants representing widely different types, and seed from each of them were grown the next year at the Central Experimental Farm, Ottawa. If the normal mode of reproduction is by self-fertilization, it was logical to assume that each plant would breed true to type and produce a uniform progeny. This proved to be the case, there being no observable variation in the plants from each parental type. By 1920 over one hundred different strains of western rye grass, collected in various parts of Canada, had been grown at the Central Experimental Farm. While most of these were carried in the nursery primarily for the purpose of demonstrating and testing the constancy of the different types, it had already become evident that some of them were much superior to others as forage plants and a few promised to become of special agricultural value.

During the last eight years, larger numbers of individual plant progenies of western rye grass have been grown and observed by Dr. G. P. McRostie, Agrostologist, Central Experimental Farm, Ottawa and the writer. These studies also have shown that, in the main, the progenies of single plants are true-breeding but occasionally segregation occurs indicating that some plants are heterozygous for one or more characters. It is evident, therefore, that some natural crossing takes place but the extent to which it occurs has not been determined.

Variation in Western Rye Grass

Malte (*5*) refers to the "tremendously large number of forms" of western rye grass which he observed in nature. Many of these he grew in his nursery. Any one who has visited the breeding nurseries at Ottawa or Saskatoon will be impressed also with the variability of this grass and the opportunity which it presents for the selection of superior agricultural types. Some of the more obvious characters in which the strains differ are color, width and texture of leaf; fineness, height and strength of stem; length and density of spike; earliness; and productivity. Less obvious variations occur with respect to a number of seed characters such as awning of the lemma, hairiness of the lemma and hairiness of the rachilla. These can only be observed under strong magnification.

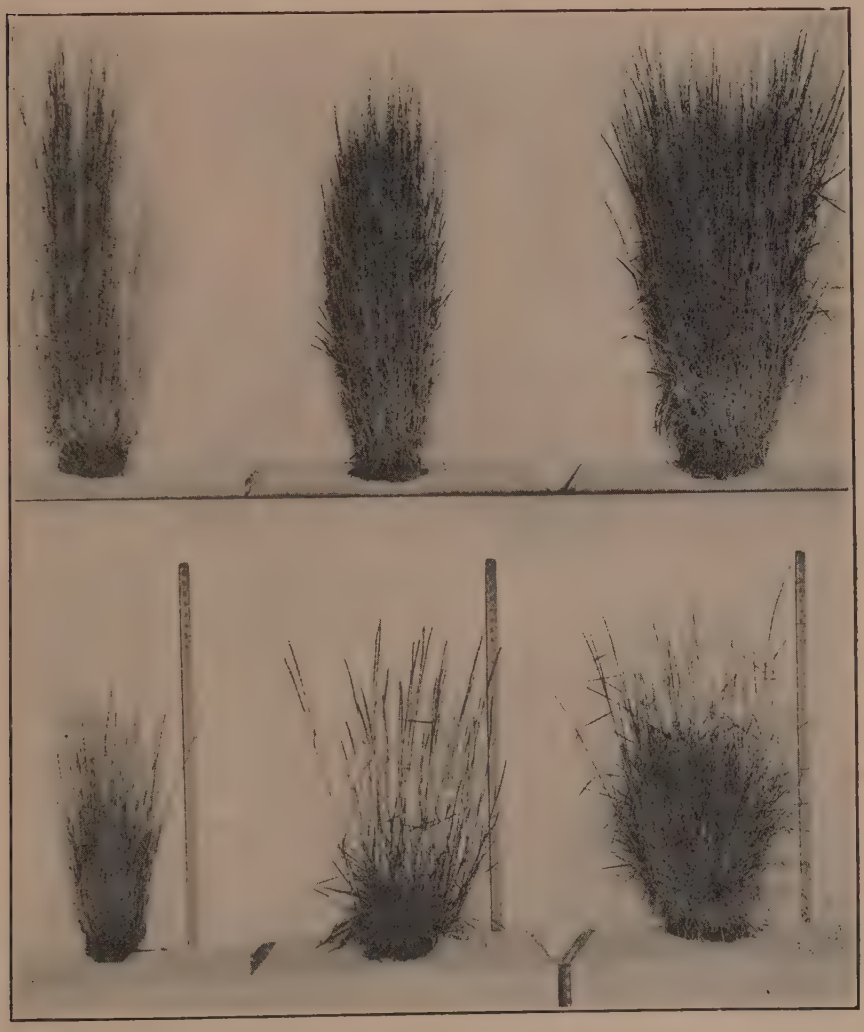

Figure 1. Single plants of western rye grass showing diversity of type. Field husbandry department experimental plots, Saskatoon.

The study of seed characters has assumed considerable importance owing to the necessity of being able to distinguish seeds of western rye grass, *A. tenerum,* from quack grass, *A. repens,* the latter species being listed in the Canada Seeds Act as a primary noxious weed and frequently occurring as an impurity in the seed of brome grass and also of western rye grass. Papers dealing with the distinguishing characters of the seed of *A. tenerum, A. repens* and *A. Smithii* have been published by Hillman (*4*), Dahlberg (*1*), Sarvis (*10*), Foulds (*2*) and Henry (*3*). Miss Henry's paper is especially helpful in distinguishing seeds of the different species. Foulds' paper was read before the Western Canadian Society of Agronomy in December 1927. It describes not only the seeds of the three species mentioned but also some thirteen others. Both papers contain many excellent original drawings by the authors.

Foulds (*2*) classified all the commoner species of Agropyron in four main groups as follows: (1) *A. repens* group; (2) *A. tenerum* group; (3) *A. Smithii* group; and (4) *A. dasystachyum* group. The *A. tenerum* group proved to be the most variable in seed characters but all forms were found to "possess the same general shape, color, texture, shape of callus and of rachilla, etc., but to vary through a graduated series as regards the pubescence of the callus and of the rachilla, and the absence, presence or length of awn". *A. Richardsonii,* which was included in this group, may easily be distinguished from the other forms by the hairs of the callus and rachilla which are two to three times as long and by the apex of the lemma which is trifurcate, the central nerve projecting to form an awn three or four times the length of the lemma proper. All of the other forms of *A. tenerum* are either awnless, awn pointed or have a short awn approximately one-quarter the length of the lemma. The main difference, therefore, in seed characters between the several forms of *A. tenerum* appears to be chiefly that of degree of pubescence of the callus and rachilla.*

Peto (*8*) has investigated recently the chromosome number of six species of *Agropyron*... These were found to fall into three groups with haploid numbers of 7, 14 and 21 chromosomes. *A. tenerum* and *A. cristatum,* the two most important cultivated species have fourteen, and this group also includes *A. Richardsonii,* while *A. repens* has 21 chromosomes.

Breeding Experiments

It was recognized and pointed out by Malte (*5*) that improved strains of western rye grass could be obtained readily by selection from the numerous naturally occuring types. Since the normal mode of reproduction was by self-fertilization, he suggested that the testing and propagation of promising strains from individual plant selections would lead directly and easily to improved varieties. All of the breeding work with western rye grass which has been undertaken in recent years has proceeded on the assumption that this grass is self-fertilized and no effort has been made to prevent cross-pollination. That some degree of cross-pollination takes place has become evident by observing large numbers of individual plant progenies in which families occasionally occur which segregate for one or more characters. In

*The writer is indebted to Mr. Foulds for examining and reporting on the seed characters of a number of promising strains from the breeding nursery.

the main however, the great majority of single plant selections appear to breed true. In view of the present status of western rye grass breeding and the additional work which would be required to provide artificial protection against cross-pollination, the method of straight selection seems to be justified. Improved strains may be purified for minor characters by selection within self-fertilized lines, if this is deemed advisable

Western Rye Grass Improvement at the Dominion Experimental Farms.

Extensive experiments in the breeding of western rye grass have been carried on at the Central Experimental Farm, Ottawa, under the direction of Dr. G. P. McRostie, successor to Dr. M. O. Malte as Dominion Agrostologist and Mr. R. I. Hamilton, Assistant Agrostologist. When Dr. McRostie took over the work in July 1922 he received from his predecessor "a few superior strains of western rye grass" *(6)*. Seven of these had been sent in 1920 to the Dominion Experimental Station at Scott, Saskatchewan, where they were tested for two years. Strain No. 5 gave the highest yield of seed and it was second in yield of hay. The strain appeared to be quite leafy and the aftermath slightly heavier than most of the others tested. This strain was later introduced, as a combined hay and pasture type under the variety name "Grazier".

In 1922, plots of 130 selections of western rye grass were set out in the grass nursery at Ottawa with individual plants spaced one foot apart each way. This method of growing the strains was adopted so that it would be possible to study the uniformity of the plants in each. Eighty of the most promising strains were again tested in 1925 as to their ability to yield paying crops of both fodder and seed. The results are presented on Page 16 of the Report of the Division of Forage Plants for the years 1924 and 1925. On the basis of these tests fifty-four strains were chosen for testing on Western Experimental Farms located in those areas which are naturally adapted for the growing of this crop.

In the spring of 1925, another strain known as "Fyra" was given general distribution for the first time. This strain was multiplied and distributed by the Field Husbandry Department, University of Alberta, as the best one of a number of Ottawa selections tested at that institution. McRostie *(7)* states that "both 'Grazier' and 'Fyra' have proven more desirable than the commercial mixtures generally sold". The results of more recent tests indicate that some of the Ottawa strains, which are also being studied at the Scott Experimental Station, may prove even better than either of the two named varieties previously distributed.

The Dominion Experimental Station at Scott, Saskatchewan, is located in a district which is admirably adapted to the growing of western rye grass. Experience has shown that no other hay crop was so generally satisfactory under the conditions in that locality. It was therefore decided to test the entire fifty-four Ottawa strains at this station. These were seeded in the spring of 1926 in replicated one one-hundredth acre plots. All of the strains were again seeded in 1928, the plants being started in the greenhouse and transplanted into plots, the individuals spaced six inches apart in rows one foot apart. A careful comparison is being made by Mr. F. M. MacIsaacs

between the various strains of western rye grass under test with a view to finding out which are the most productive and desirable for forage. Notes are being taken on the root system, emergence, stooling, habit of growth, color, maturity, number of leaves per plant, percentage of leaf and stem, thickness of stem, green weight and dry weight. Quantitative measurements were found necessary for the accurate determination of leafiness and quality.

Western Rye Grass Improvement at the Field Husbandry Department University of Sasatchewan

The breeding of western rye grass was begun by the Field Husbandry Department at Saskatoon in 1922 when the writer, accompanied by Mr. J. G. Davidson secured seed of one hundred and fifty individual plants within a radius of ten miles from the city. The net result of an intensive study of these selections has been the isolation of a high yielding strain. This selection has been designated in the breeding nursery as Strain No. 8, and the new name by which the improved variety shall be known is "Mecca" western rye grass. No seed of this strain thus far has been distributed.

The "Mecca" strain of western rye grass has yielded significantly high in both hay and seed in every test that has been made, the increase over commercial seed being as great as thirty-seven per cent in yield of hay and thirty-eight per cent in yield of seed. Its forage qualities are exceptionally good. The strain also appears to be very uniform in plant and seed characters with the exception of some variability in pubescence of the rachilla. In view of the remarkable consistency with which this strain has outyielded the best commercial seed, it was thought that a brief outline of the entire breeding project might be of some interest, together with the method of testing and a statistical analysis of the results obtained. The figures which are presented in the accompanying tables include every test which has been made except that of the first seeding from original plants. All strains however, are not included in each table since Strain No. 8 is highest in every test and we are chiefly interested in a comparison of this strain with unselected commercial seed. Yields were recorded in terms of cured hay which were calculated from the green weight on the basis of samples taken at harvest time and dried to a uniform moisture content.

The nursery containing progenies of one hundred and fifty original plant selections consisted of rod row plots with numerous checks sown with commercial seed. Of each selection there were also ten plants spaced for individual plant study. After three years in which yields were taken and extensive observations made on various plant characters, twenty-one of the most promising were singled out for further comparison. Selection was based on yield and desirability of forage type.

In 1925 the selected twenty-one strains were seeded in a comparative test consisting of rod rows, each replicated nine times, with check plots of the best commercial seed available at frequent intervals. These were harvested for three years in succession, six of the replicated plots being used for hay yields and three for seed yields. Table 1 gives the average yield of hay produced by each strain. It also gives the relative placing of the different strains in each year and the order of placing for the three year average.

Figure 2. Western rye grass nursery showing original selections in rod rows. Field husbandry department experimental plots, Saskatoon.

TABLE 1. *Comparison of hay yields of western rye grass strains in rod rows of six systematically distributed plots, sown 1925.*

Strain No.	Lbs. hay per plot 1925	1926	1927	Average* 1925-27	Strain numbers in order of yield 1925	1926	1927	Strain numbers in order of av. yield 1925-1927
Check	4.40	4.30	4.17	4.29	8	8	9	8
1	4.43	3.68	4.05	4.05	7	9	6	9
2	4.31	4.13	4.66	4.37	9	3	11	7
3	4.56	4.41	4.24	4.40	5	17	2	11
4	4.59	4.04	3.92	4.18	16	16	8	16
5	4.81	4.16	4.26	4.41	19	20	7	14
6	4.03	3.87	4.82	4.34	11	14	14	5
7	4.98	4.11	4.59	4.56	10	check	18	3
8	5.45	4.54	4.59	4.86	12	21	12	2
9	4.91	4.43	4.89	4.74	4	11	15	6
10	4.61	3.36	3.89	3.95	3	5	5	12
11	4.69	4.19	4.73	4.54	13	15	3	15
12	4.60	4.07	4.36	4.34	18	2	check	check
13	4.55	4.01	3.92	4.16	15	7	21	18
14	4.42	4.32	4.57	4.44	1	12	16	21
15	4.50	4.15	4.35	4.33	14	4	19	4
16	4.77	4.40	4.16	4.44	check	13	1	13
17	4.34	3.41	4.03	3.93	21	18	17	20
18	4.51	3.95	4.37	4.28	17	6	20	1
19	3.72	3.83	4.08	3.88	2	19	4	10
20	4.19	4.37	3.93	4.16	20	1	13	17
21	4.36	4.22	4.17	4.25	6	10	10	19

*Probable error calculated from the yields of check plots for the three year average is 3.2 per cent; calculated from an analysis of the variance, 3 per cent; odds 30:1 in favor of Strain 8 as compared with the average yield of check plots.

It will be seen that Strain 8 is at the top in two years out of three and heads the list for the average of three years. The probable error for an average of three years was 3.2 per cent. The odds in favor of Strain 8 as compared with the check plots was 19:1. Correlation however, was not taken into account in calculating the probable error of a difference. The probable error was then calculated from strain yields by an analysis of the variance, thus eliminating much of the correlated variability. This gave

odds of 30:1 indicating a significant difference. A still more exacting comparison resulted when the odds were calculated from the differences between the yields of paired plots of Strain 8 and the adjacent checks for the three year period. The figures are given in table 2.

TABLE 2. *Comparison of Strain 8 with adjacent checks by "Student's" Method for the crop years 1925-1926-1927.*

	Yields of hay Strain 8	Yields of adjacent check	d	d^2
	Pounds per plot			
1925	4.46	4.24	+ .22	.0484
	5.44	5.24	+ .20	.0400
	6.94	6.29	+ .65	.4225
	6.88	6.31	+ .57	.3249
	5.19	4.34	+ .85	.7225
	4.77	3.66	+ 1.11	1.2321
1926	10.59	10.06	+ .53	.2809
	11.25	12.53	— 1.28	1.6384
	8.69	8.47	+ .22	.0484
	11.59	11.31	+ .28	.0784
	14.16	12.16	+ 2.00	4.0000
1927	11.00	9.62	+ 1.38	1.9044
	12.38	11.38	+ 1.00	1.0000
	7.19	7.19	0.00	0.0000
	8.87	7.81	+ 1.06	.0036
	5.75	6.19	— .44	.1936
	6.69	7.19	— .50	.2500

Odds in favor of Strain 8 = 74:1

The paired comparison between Strain 8 and adjacent check plots from commercial seed for all plots in each of three years (Table 2) gives odds in favor of the former of 74:1. Apparently the correlation between nearby plots was very high in this experiment. The actual increase of the new strain in this test is not large but its superiority in yield of forage is very evident, as measured by statistical methods.

Figure 3. Rod rows of western rye grass in the nursery which exhibited typical differences in habit of growth. Field husbandry department experimental plots, Saskatoon.

In 1926 and 1927, three of the nine plot replicates of each strain were harvested for seed. The seed yield data is presented in table 3. In this case the results are very outstanding. Fourteen of the selected strains gave seed yields which were significantly higher than the checks. The better yield of seed can be attributed in part to the greater uniformity and more even maturity.

TABLE 3. *Comparison of seed yields from western rye grass strains in rod rows of three systematically distributed plots, sown 1925.*

Strain No.	1926	1927	Average 1926-27	Strain numbers in order of yield 1926	1927	Order of Av. yield 1926-1927
	Grams per plot					
Check	381	222	302	11	8	11
1	486	279	383	8	11	8
2	422	294	358	1	17	17
3	309	237	273	17	2	12
4	428	275	352	12	12	1
5	390	284	337	15	16	15
6	361	246	304	20	5	2
7	359	279	319	21	14	4
8	512	322	417	4	1	20
9	313	246	280	2	7	14
10	399	256	328	14	4	16
11	560	322	441	18	15	5
12	482	289	386	10	20	21
13	353	198	276	16	10	18
14	412	284	348	19	18	10
15	466	270	368	5	6	7
16	398	285	342	check	9	19
17	483	298	391	6	3	6
18	408	256	332	7	21	check
19	396	232	314	13	19	9
20	437	260	349	9	check	13
21	432	237	335	3	13	3

Probable error two per cent. Differences highly significant. Correlation between seed yields for 1926 and 1927 = .77 ± .06. Increase in the yield of Strain 8 over the check is 38 per cent.

A very striking and rather unexpected feature of the data is the consistency with which most of the strains yielded seed for the two years. When seed yields for 1926 and 1927 were correlated a coefficient of .77 ± .06 was obtained, indicating a very strong tendency for high and low yielding strains to repeat their performance year after year.

The probable error for the two year average was only two per cent and the differences between high yielding strains and the checks is very significant. It is evident that Strain 8, which came second in average yield, is very much superior in yield of seed in this test to the best commercial western rye grass, the difference amounting to thirty-eight per cent.

The results of another comparative test sown in 1926 are given in table 4. Only the results of Strain 8 and adjacent check plots are listed. Each strain was replicated ten times and the plots were harvested two years for forage and one year for seed. The evidence, especially in yield of forage, is strikingly in favor of Strain 8. In 1926 the difference in yield of hay is nineteen per cent with odds of 1476:1. In 1927 the difference is a little less but the odds are greater. The increase for yield of seed in 1928 was fifteen per cent but the odds were small.

TABLE 4. *Comparison of yields of hay and seed between Strain 8 and adjacent checks from best commercial seed in ten systematically distributed row plots.*

1926 Hay: lbs. per plot		1927 Hay: lbs. per plot		1928 Seed: grams per plot	
Check	Strain 8	Check	Strain 8	Check	Strain 8
4.06	4.47	11.00	12.75	112	122
3.25	4.62	11.44	13.44	119	119
4.37	4.56	11.37	12.62	102	159
3.51	3.56	9.94	10.94	91	85
3.22	3.91	9.62	10.94	104	83
3.16	3.41	9.94	10.25	81	109
3.00	4.41	9.37	11.00	80	147
3.25	4.34	9.81	11.75	69	114
4.06	4.75	12.31	13.37	111	90
4.28	5 00	13.50	13.94	81	62
Av. 3.62	4.30	10.83	12.10	95	109
Diff. 19 per cent		12 per cent		15 per cent	
1476:1		9999:1		9:1	

It was decided next to test a few of the most promising strains, in a way which would be exactly comparable with field conditions. Six strains were chosen on the basis of previous performance, and these together with the best commercial western rye grass seed were sown in small plots arranged at random in a Latin Square. This provided for seven replicates of each of the seven lots to be tested. Each plot was a rod long with nine drills six inches apart and provision was made for removing the border rows as well as a foot at each end of the plot. The yield results are given in table 5.

TABLE 5. *Comparison of selected strains of western rye grass. There are seven plots of each arranged at random in a Latin Square.*

Strain No.	Average yield of hay (ounces per plot)	Increase over Commercial seed
8	68.1	+ 11.4
7	61.7	+ 5.0
14	58.4	+ 1.7
Commercial	56.7	+ 0.0
9	56.6	— 0.1
15	53.9	— 2.8
16	52.7	— 4.0

Probable error 2.26 per cent. Signif. Diff. = 3 × $P.E._d$ = 5.5 oz. Increase in yield 20 per cent. Odds in favor of Strain 8 over Commercial seed = about 20,000:1.

The difference in yield of hay between Strain 8 and the check plots in this experiment is over six times the probable error of the difference. The odds in favor of Strain 8 are therefore very high.

Again in 1928 a comparative test of western rye grass strains were seeded, this time in large plots 1/32 acres in size and replicated three times both with and without a nurse crop. This experiment occupied one and one-quarter acres of land. The season was so favorable that the plants were fully headed and one to two tons of cured hay per acre was harvested in the fall. The results, which are presented in table 6, show that Strain 8 is a consistently higher yielder than the check plots from commercial seed, the former producing on the average thirty-seven per cent more hay than the latter. In this test, as in all the others, the stands were practically perfect and counts of plants from three locations in each plot showed that the number

per unit area was practically the same. It is evident from the statistical analysis that the results possess a high degree of reliability.

TABLE 6. *Comparison between Strain 8 and best commercial seed of western rye grass in yield of hay from three systematically distributed 1/32 acre plots. Seeded 1928.*

No. of replicate	Pounds hay per acre	
	Strain 8	Commercial seed
1	3528	2667
2	3774	3282
3	3097	2196
Average	3313*	2407

*Increase in yield 37 per cent.

In each of the three years 1925, 1926 and 1927, samples of the different strains under test were taken for the purpose of studying the relative proportion of leaf to stem. This determination can be made with great accuracy, the method being to work with one hundred gram samples in duplicate of dried material, and taking one culm at a time, break them at each node after which the leaf may be separated from the stem entire.

The average leaf percentages for the three years were 42.7 $\pm$ 0.61, 52.4 $\pm$ 0.33 and 34.5 $\pm$ 0.59 respectively. Contrary to expectations no strain was found to be significantly high in proportion of leaf to stem. It was also evident from the figures that there was little consistency in the leaf percentage figures of the different strains when any two of the three years were compared. In order to determine this relationship more precisely, correlation coefficients were calculated and values obtained as follows:

1925 with 1926 $r = .1742 \pm .1542$
1926 with 1927 $r = .0012 \pm .1417$

It is apparent from these results that there was no consistent difference in leafage between the strains of western rye grass, at least as far as it has been possible to determine. There is this to be said however, that all of the twenty-one strains studied for this character were selected with forage value in mind. Had a few of the less valuable types been included, it is quite probable that some would have been shown to be consistently more leafy than others.

Chemical determinations for protein were made by the Department of Chemistry of the University of Saskatchewan in each of two years. A small difference was found in favor of the improved strain but it is not considered significant.

Increase plots of Strain 8 were seeded in 1928 and a limited quantity of seed may be available for distribution this fall.

SUMMARY

1. A species of wheat grass, *Agropyron tenerum*, known locally as "western rye grass" is indigenous to Western Canada and is highly regarded as a productive drought resistant perennial forage plant in the provinces and states of the northern Great Plains area of North America. It is the only native American species of perennial grass plant that has been introduced extensively into cultivation and it is the only perennial cultivated grass that is normally self-fertilized. The great variety of forms which occur in nature and the mode of pollination makes the improvement of this crop by breeding a comparatively simple undertaking.

2. An outline has been given of the present status of western rye grass breeding and also a statement of what has been accomplished to date by plant breeders toward the improvement of this species of grass as a cultivated crop.

3. Extensive breeding projects for the improvement of western rye grass by selection have been under way for several years at the Canadian Dominion Experimental Farms and at the Field Husbandry Department, University of Saskatchewan, Saskatoon.

4. Two improved strains of western rye grass, selected and tested by the Central Experimental Farm, Ottawa, have been increased and distributed under the variety names "Grazier" and "Fyra". The former was the best Ottawa strain in the first tests made at Scott, and the latter, the best of several Ottawa strains tested and distributed by the Field Husbandry Department, University of Alberta. It is anticipated that some of the numerous later Ottawa selections, which are being studied also at the Scott Experimental Station, will prove of special agricultural value.

5. Breeding work at the Field Husbandry Department, University of Saskatchewan, has resulted in the selection of a high yielding strain which has been shown by extensive field plot trials to yield as much as thirty-seven per cent of both hay and seed more than the best commercial western rye grass. This strain has been given the variety name "Mecca". It is anticipated that a limited quantity of seed will be available for distribution in the spring of 1930.

LITERATURE CITED

1. Dahlberg, R. C. Identification of the seeds of species of *Agropyron*. Jour. Agr. Research, *3*: 275-282, 1914.
2. Foulds, F. E. A study of the comparative morphology of the seeds of *Agropyron*. Sci. Agr., *10*: 3, page 200, November, 1929.
3. Henry, H. The seeds of quack grass and certain wheat grasses compared. Jour. Agr. Research, *35*: 537-546, 1927.
4. Hillman, F. H. The distinguishing characters of the seeds of quack-grass and of certain wheat grasses. U.S. Dept. Agr., Bur. Pl. Ind. Circ. 73, 1911.
5. Malte, M. O. Breeding methods in forage plants. Proc. Western Canadian Society of Agronomy. Vol. 1, 1920.
6. McRostie, G. P. Report of the Division of Forage Plants, 1922. Dom. Exp. Farms, Ottawa.
7. ———— Report of the Division of Forage Plants for the years 1924-1925. Dom. Exp. Farms, Ottawa.
8. Peto, F. H. Chromosome numbers in the Agropyrons. Nature, Aug. 1929.
9. Sampson, A. W. Native American Forage Plants. John Wiley & Sons. New York, 1924.
10. Sarvis, J. T. Suggestions for the identification of the "seeds" of quack grass (*Agropyron repens* (L). Beauv.) western rye grass (*Agropyron Smithii*, Rydb.) and slender wheat grass (*Agropyron tenerum*, Vasey.)—paper published privately, 1913.

GENETIC METHODS OF ANIMAL PRODUCTION*

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It is not inappropriate that this convention, assembled in a region in which the plant is paramount, should allocate so much of its time to discussions of livestock improvement, for it can be safely predicted that as time passes, and it passes quickly, animals will assume an ever increasing importance in the agricultural operations of these parts. The very existence and robust health of the Western Canada Society of Animal Production are evidence that this is so. Now is the time, before the need to increase the animal population of these provinces becomes clamant, to construct sound policies that shall ensure that the livestock as it multiplies shall be of the highest quality.

In considering such policies we have the very considerable advantage of being able to profit, if we so wish, from the experience gained from other, yet essentially similar, fields. A review of what has been done and of what has happened will lead us directly to the conclusion that the greatest measure of success has attended those efforts which have been noteworthy for organized concerted action. We are allowed to postulate that if the livestock industry of Canada is to contribute fully to the development of the country the following projects must be contemplated. There must needs be developed national schemes for: (1) increasing production, (2) continuous improvement, (3) standardization and uniformatization of animal products, and (4) marketing. Canada must discover what livestock commodities she can produce; she must produce these economically and she must produce them in bulk. Unless she proposes to produce quality in volume Canada's livestock industry must remain a purely parochial interest.

The problems easily fall into two categories; firstly, those which concern the reparation of deficiencies in production and secondly, those which relate to the securing to the producers a fair share of the selling price. Of the two, the problems of marketing are the more serious but their solution benefits the agricultural community immediately and enormously. One notes with the greatest interest and enthusiasm the growth of the many co-operative marketing schemes in Canada. Without doubt these are the means by which the agriculturists may hope to retain for themselves some reasonable degree of economic prosperity. The further development of these organizations will be encouraged by all who are sincerely interested in agricultural affairs. Their success can only be prevented by disloyalty among their members.

The problems that refer to production are relatively simple and easy of solution. There would seem to be no insuperable difficulty in producing any commodity; the real problem is to state exactly, and to understand precisely, what is to be produced. The methods of production present no difficulty, the policy of production is usually vague and incoherent. Let me turn to the problems of wool improvement in order to illustrate my

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meaning. In Great Britain one hears continuously the cry for fleece improvement but to one who listens there comes the impression that the demands that are made are altogether vague and indefinite, there is not, and apparently can not be, any general agreement among those concerned as to what is meant by improvement. Presently the textile point of view dominates the councils of the breeders for the latter are unorganized, inarticulate or incoherent, and to the manufacturer of woollen goods the sheep's fleece would seem to be a God-sent gift for the very purpose of making socks for humanity at a reasonable profit. To him the sheep is merely a vehicle for the fleece, and improvement implies that the wool shall be finer, kemp and pigment free, more uniform and produced in greater amount than it is now, but at the same time that it shall be purchasable at the price now given for such as is full of qualities which the wool buyer regards as serious defects. In short the manufacturer, unwilling to modify his machinery, wishes the breeder to cheapen textile production but offers to him no share of the savings.

The breeder approaches the matter from an entirely different angle. He, knowing the general conditions of his own farm, and of his locality, sets himself the task of breeding a stock that under the existing market conditions is most profitable to himself. His problem is to build up a flock which will flourish on his particular land, and under his peculiar system of husbandry—for this is but the expression of himself—and which shall provide flesh and fleece which he can sell easily and well in the markets which are available to him. He has to consider fertility, milk yield, growth rate, general hardiness and fitness in relation to the peculiar pasturage of his land, mutton points no less than fleece quality and quantity. His view is that the fleece must help his sheep to thrive or at least that it must not embarrass the general well-being and well-doing of his stock.

But even though the interests of manufacturer and breeder are very different there is no real reason that they should clash. It can be stated without fear of contradiction, that if and when it is demonstrated that it is far more profitable financially to grow a particular kind of wool, and if it is shown that such wool can be grown without serious uncontrollable harm to the living sheep, then the breeder will produce it in any quantity. But if such wool is to fetch no higher price than the present clip or if the demand for such wool is to be but transient and uncertain, then no breeder will pay any serious attention to the cries of those who demand this or that but who are not willing to encourage its production by the only possible means—that of giving a higher price for it. The farmer knows that mutton can always command a fair and steady price in the regional markets, whereas the fluctuations in the price of any particular grade of wool are profound and most unsettling. He, therefore, regards mutton production as the more important aspect of sheep husbandry and wool merely as a by-product for which, in the absence of any sound system of coöperative marketing, he may perhaps hope to get some fair financial recompense.

Before there can be any serious attempt at improvement of the fleece, the desired standards must be defined and the following questions must be answered: What is the relation between the characterization of the birth coat and the adult fleece? Is it possible to predict the latter from the

former and so select among the lambs? Is it possible to evolve a stock that shall be sufficiently covered during infancy and yet produce a fine woolled fleece in maturity? Is there a significant relation between the texture and weight of a fleece and the general vigor of the animal? Are the fine woolled individuals inherently less hardy than their relatives with stronger wool? Is it relatively more profitable to produce a greater quantity of stronger wool or a smaller quantity of finer? These are questions that will be answered by the breeder and not by the manufacturer. A preference on the part of the manufacturer for Merino quality of wool will not persuade the sheep breeders of Britain to replace their own flocks with Merinos. Merino wool can be produced profitably only under social, agricultural and climatic conditions similar to those which obtain in Australia or South Africa. The production of the finest Merino wool is presently restricted to a relatively small area of the world. The fact that there are so many breeds in Britain is to be explained only on the assumption that that country cannot be treated as a unit. Each breed has developed under the impress of local conditions to fulfil a particular purpose in a peculiar environment and the trademarks of a breed are its least important distinguishing features.

If and when it has been determined that in relation to existing regional conditions, the ideal fleece, from the breeder's point of view, is such and such, it can then be stated by the textile specialist that such wool falls most easily into a particular class—carpet wool, hosiery wool or one of the others; then the breeder can be told exactly wherein his clip falls short of the ideal for those particular purposes. Finally he can be encouraged to breed out these defects. If it is worth his while he will do it quite easily and quickly, the rate being determined by the size of the bonus. But at the present time a deal of harm is being done by those who seem to encourage the breeder to grow a hosiery fleece on a carpet breed without first having demonstrated that from the point of view of that particular partnership—sheep and sheep breeder—the hosiery quality is the better.

Questions of policy fall outside the scope of genetics but this does not stay the flood of enquiries concerning policy that flows into the laboratory. The personal factor in agricultural practice is of prime importance and no one but the agriculturist himself can decide upon the policy of his farming. A well balanced education is a prerequisite to really successful farming today for the farmer must not only be able to check the costs of production against the prices he is likely to receive but he must also be alive to the value of the contributions that science has made and is making, and he must know how and where he may obtain a knowledge of these for himself. One does not expect a breeder to be a botanist, bacteriologist, chemist, zoölogist, geneticist, meteorologist, geologist in addition to being versed in bookkeeping, building construction, engineering, and surveying, but it is indeed most desirable that he should understand the language of these subjects and be able to follow their arguments. Nowadays the farmer is becoming indebted more and more to the laboratory but science is of assistance to the agriculturalist only if he knows the primary business of farming and is competent to apply its teachings to his own peculiar set of circumstances. The policy of farming must change with the changing demands of the markets and it behoves the agriculturalist to preserve the open mind. He must ever be alive to sense

new openings, new opportunities, and be competent to take advantage of them. The methods of husbandry to which he is accustomed must never be regarded as immutable, for they, like all else, must yield to changing times. It is only when the breeder knows what he wishes to breed that the geneticist can come to his aid, showing how through breeding, individuals exhibiting the characterization that has been defined, may be obtained.

The idea of improvement, then, demands a standard of excellence. The ideal type is that which in virtue of its characterization so fits the habitat in which it has its being that it achieves the fullest expression of its hereditary constitution and thus fulfils adequately the destiny for which it was intended. Before any standard of excellence can be constructed there must be available exact information concerning the purposes for which the stock is to be bred and concerning the habitat, (climate, soil husbandry) in which it is to live. When habitat and destiny have been defined it is no difficult task to produce by selection or by hybridization, the particular combination of hereditary characters which constitute the ideal, this having also been defined in advance.

The methods of improvement through breeding are simple and straightforward. Developments in genetics have not changed them but merely explained their success. Bakewell, for example, when he set himself the task of improving the Leicester and the Longhorn, employed two methods, both genetical. Having first chosen the best individuals he could find—the best according to his own standards—he inbred in order to secure uniformity of type. Further, he used, as sires of the succeeding generations, only those males which, when used on the stock of his neighbors, begot the best offspring—the best according to his standards, an early example of the progeny test and very sound genetics. Many dairy farmers of today could imitate Bakewell with advantage.

Bakewell had many disciples and among them there were greater artists than he; the Booths, the Collings, Bates, Amos Cruikshank and William Duthie all contributed to the making of the modern Shorthorn. Watson and McCombie both played prominent rôles in the improvement of the Aberdeen Angus, as did Price and Hewers, in the case of the Herefords. All of these, as did others like them in the case of other breeds, followed the methods of Bakewell and in providing superior individuals did two things, they provided the stimulus to improvement and they provided the means.

The Collings' "white heifer that travelled" and "the Durham ox" excited great interest in the possibilities and advantages of livestock improvement and the landed proprietors of the country extended this. Not only did they breed improved stock but their tenants made full use of the sires thus made available. Then came inevitably the rise of agricultural societies with their shows which catered for the competitive nature of the animal-loving Briton; breeding became a sport as well as a business and its success was thus assured. Then developed automatically the herd and flock book societies, each gathering round its own particular breed, to protect, to improve and to advertise it.

And so events marched on until the beginning of the present century when as far as Scotland is concerned, an event of the greatest importance occurred. The west of Scotland farmers, John Speir in particular, introduced the practice of milk recording. The notion of the assessment of value

on record of performance took definite shape. At last the eye and the touch of the judge were replaced by the precise impersonal measurement—another instance of sound genetical procedure which has, in its use, been extended to many other animals of economic importance.

The final chapter of the story of animal improvement, in so far as it is yet written, is one which deals with State intervention. That which no single breed society may do, the State can do; it can deal with the livestock population of the country as a whole. The methods of improvement have been of two kinds, negative and positive. Negative methods comprise all those which have for their object the prevention of the spread of bad germplasm among the livestock population of the country. By bad germplasm is meant those hereditary constitutions which include factors corresponding to characters which are harmful to their exhibitors or definitely unprofitable to the breeders and which cannot be easily and cheaply repaired. Lethal factors which lead to the development of characterizations that render their exhibitors non-viable are present in considerable numbers in the hereditary constitutions of the domesticated animals and are responsible for much prenatal and early post-natal death. Hereditary defects and derangements which cannot as yet be cured, or which can be repaired only at considerable expense, are common and lead to much loss. Such undesirable factors must be removed from the germplasm of the stock by appropriate genetical methods.

But in addition to the obviously undesirable, the grossly abnormal and the sterile, there exist in all countries vast numbers of inferior animals, differing from the superior in virtue of their hereditary constitutions. Their characterization is not hopelessly bad but it is not as good as that of others. Since manifestly it is sound policy to breed only the best there is no point in propagating the relatively unsatisfactory. Further, since improvement implies manipulation of hereditary constitutions it is eminently desirable that the pedigrees of all animals used for breeding shall be known. For this reason the use of the scrub male—the unknown—must be discouraged and even prevented.

Positive methods aim at the provision of stock of known genetic constitution and possessing an accurate record of performance. Mechanisms of considerable size and complexity are required if the object is to be attained. First of all there must be a mechanism for the provision of knowledge concerning the genetics and the sex-physiology of the animals to be improved. The various characterizations must be taken to pieces by genetical analysis before there can be any synthetic re-combination of desirable characters to form the ideal type. Moreover, since qualities of economic importance do not permit of easy definition, formal genetics will not suffice, physiological genetics must be developed, for we must have knowledge of how the gene, in its action, produces its end result, the character.

Next there must be a mechanism for the construction of standards. This would seem to be one of the functions of an agricultural college. Consider for a moment the standard of the approved stallion. Among the many other qualities required of him there are two of outstanding importance. His fertility ratio must be satisfactory and his offspring must be specimens of excellent individual merit and highly fertile, for there is no satisfaction in having an excellent characterization unless it can be transmitted.

The selection of such stallions must be governed by their breeding performance no less than by their appearance. All premium schemes must be conducted as experiments designed to provide data of scientific interest and value and these data must be accumulated. The most extensive genetical experimentation with domesticated animals that has been carried out so far has taken the form of the various premium schemes but they have been of no value whatever for the reason that no sufficiently comprehensive records have been maintained. In my opinion all licensed stallions and premiumed bulls should remain the property of the State and to certain members of the staffs of the regional agricultural colleges should be given the opportunity of collecting and examining the data that are made available as a consequence of their use.

The State has endeavoured to do the very things which previously were done by private individuals and organizations. It has provided the stimulus to improvement—education and research—, and it has provided the means—improved stock. It has encouraged the multiplication of good stock and has prevented the spread of bad—good and bad being terms that refer to the quality of the germplasm of the individuals concerned. The provision of approved sires, e.g. the schemes of premium bulls and stallions, and of approved stock, e.g. eggs from State controlled poultry plants, are examples of state intervention which assumes that the breeders generally are either incapable of assessing the value of an individual or of individuals at all accurately, or else cannot, for financial reasons, provide these for themselves. Compulsory sterilization of the undesirable has been invoked to amplify the benefits thus secured. In addition to these genetical methods of stock improvement the State has adopted policies which have dealt with the problems of disease prevention and control for it became obvious that it was no good improving the constitution of stock if disease were permitted to wipe it out.

It can be stated dogmatically that there is only one sure method of improving the live stock of a country and that is by improving the breeder. Do this and the rest will follow as the night the day. This can be done by improving his education and by offering rewards for ability. The stimulus of the teacher who loves and who knows his subject is the first essential. Since breeding is applied biology, this science must loom large in the educational curriculum of the future breeder. He must be inspired to cultivate an appreciation of the fitness of a type in relation to its habitat and to its destiny. It is here that stock judging, biological standards being used, can play its part. The shows now-a-days are not such important agents in livestock improvement as they were in earlier days. Far too much importance is given to standards which have no relation to economic worthiness, for the showyard is losing sight of commercial realities and it tends to encourage grossly uneconomical methods of husbandry. The art of preparing an animal for the showyard is practised to the neglect of the art of breeding. At the present time the prize is awarded to the *man* who exhibits the best fitted animal and not to the *animal* that is the best, the nearest to the ideal economic type. Genetics must infiltrate the shows. The societies would be doing yeoman service to livestock breeding if they staged classes for the offspring of a single bull and of the produce of a single cow. The award

must be given to the best performer and not to the best looker. The milk record, the bacon quality, the pulling power, the egg record, must overshadow the peculiar preferences of prejudiced judges. Judgment must be on record of performance and must be impersonal.

The pig testing station, the laying trial, the wool yield test, not only for sheep but also for the Angora rabbit, are other tools which must be used by the agricultural colleges wherewith to fashion standards. But there is no need to elaborate this subject for all are well acquainted with it.

The second stimulus to improvement concerns marketing. Improvement must be shown to be worth while not only to the State but also to the individual breeder. But this is not my province.

In conclusion I would wish to ask you to consider the immensely large question of regionalization in extensive breeding. At the present time one cannot escape the impression that every country and every part of every country is striving to produce everything just as every university strives to teach everything and pays no heed to the peculiar opportunities for specialization which abound locally. It seems to me, being very ignorant of these matters, that the Empire should be organized agriculturally and that each component part of it should specialize in the production of that particular kind of stock which flourishes best in that particular environment. Climates, soils, people and theologies differ just as much as do species and breeds and it would seem reasonable to urge that from each part of the Empire should be expected that agricultural product which can be grown there most advantageously. I do not expect to hear that Canada is to compete with the West Coast of Africa in the production of vegetable oils; but I shall not be surprised to hear that each of the Provinces, without reference to its peculiar soil, climate and human qualities, is competing with all the others in an attempt to grow everything.

As I said at the beginning so I say at the end, the hereditary constitution of the individual is conditioned in its expression by the forces of the environment and before there can be improvement of stock there must be a knowledge of the environment for this is the frame into which we have to place the picture that we paint in living colours. It is impossible for Canada to produce the best of everything. She must decide what she can produce more economically and in greater bulk than can other countries. This decision having been made, then the geneticist can help in advising how such production can be achieved.

BREEDING RUST RESISTANT VARIETIES OF WHEAT—FUNDAMENTAL ASPECTS OF THE PROBLEM.*

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INTRODUCTION

Concurrently with attempts to breed rust resistant varieties of wheat certain fundamental investigations bearing on the entire problem have been conducted. As in all other lines of endeavour we progress only in so far as we understand the principles with which we are dealing. It is therefore of great interest with respect to the problem of breeding rust resistant wheats to examine the results which have been obtained from the fundamental investigations and especially to consider how this knowledge is of direct assistance in the practical breeding work.

CYTOLOGICAL STUDIES

In the first place it was observed that resistance to rust was possessed almost entirely by wheats of the durum and emmer group which are of much less value from the commercial standpoint than the *vulgare* or common wheats. With rust resistance located in one species and commercially desirable characters in another it was evident that interspecific crosses must be made. These crosses however were found to be highly sterile and at first very little progress was made. A very great deal of light was then thrown on this phase of the work by cytological investigations dealing chiefly with the chromosome numbers of the different wheat species and with chromosome behaviour in crosses of species having different numbers. These studies have been conducted chiefly by Sakamura (*21*), Sax (*22*), Kihara (*11, 12*), Thompson (*25, 26, 27, 28*), Thompson and Hollingshead (*29*), Melburne and Thompson (*15*) and Watkins (*30, 31, 32, 33, 34*). It is impossible at this time to go into the cytological work in detail and it will serve the purpose of this discussion to mention a few of the outstanding points.

First, the different wheat species were found to have different numbers of chromosomes. We have the following groups, as shown in table 1, according to chromosome number.

TABLE 1. *Groups according to chromosome number of Triticum species.*

Group	Species	Diploid chromosome number
Einkorn	*Triticum monococcum*	14
	" *aegilopoides*	
Emmer	*Triticum dicoccoides*	28
	" *dicoccum*	
	" *turgidum*	
	" *polonicum*	
	" *durum*	
	" *persicum*	
Spelt	*Triticum spelta*	42
	" *vulgare*	
	" *compactum*	

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The workers mentioned above have followed out the chromosome behaviour in many combinations of these species but we are chiefly concerned here with chromosome behaviour in crosses between varieties of the second and third groups. The crosses studied have been chiefly *dicoccum* × *vulgare* and *durum* × *vulgare*. The typical behaviour may be described briefly as follows. In the gametes of the *vulgare* parent 14 chromosomes out of the 21 appear to be homologous with the 14 chromosomes of the durum or emmer parent and in the first meiotic division of the F_1 plants these pair up and form 14 bivalents. The halves of the bivalent chromosomes separate and go to opposite poles. The remaining 7 of the *vulgare* chromosomes do not find mates in the first division and are therefore termed univalents. These divide equationally in the first division and are distributed at random in the second division.

The essential feature of this chromosome behaviour is the normality of the behaviour of the 14 bivalents, and the distribution of the univalents. As a result of the latter, gametes are produced by the F_1 interspecies hybrid which contain from 14 + 0 to 14 + 7 chromosomes — the extra chromosomes over and above 14 depending on the number of univalents that go to the pole from which the cell nucleus is formed. If the distribution of univalents is random the gametes with an intermediate number of chromosomes will occur most frequently and if these are all viable the great majority of fertilizations will result in zygotes having chromosome numbers intermediate between the parents. Exactly the reverse is true however and we find that in the F_2, plants with chromosome numbers approaching or the same as the parents are found most frequently. The cause of this has been studied in great detail and is now attributed chiefly to (1) gametic sterility (2) zygotic sterility and (3) chromosome loss in the reduction divisions. The gametes with intermediate chromosome numbers in general do not accomplish fertilization so that most of the zygotes result from combinations of 14 + 14, 14 + 21, and 21 + 21, chromosomes. The 14 + 21 combination of course gives plants which closely resemble the F_1 with 35 chromosomes. Some gametes with chromosome numbers approaching the parental ones such as 14 + 1, 14 + 2, and 14 + 5, 14 + 6, do function but an additional factor complicates matters here in that certain zygotic combinations are sterile. That is, certain combinations of say 38 chromosomes are fertile while others of the same number are sterile. The sterile combinations are frequently quite lethal and either do not grow at all or develop into very weak plants which do not set seed. It has also been observed that more F_2 plants from an interspecific cross resemble the parent of lower chromosome number than the parent with the higher number. This is attributed to the loss of univalents in the reduction divisions. These frequently lag on the equatorial plate and do not reach the poles in time to be included in the daughter nuclei.

The sum total of this work in its bearing on the practical breeding problem may be stated as follows. The normal behaviour and pairing of 14 pairs of chromosomes in interspecific crosses must result in an interchange of factors by the usual processes of chromosome segregation and crossing over. Assuming that these chromosomes are homologous the *vulgare*

characters must be due chiefly to the extra 7 pairs but there is considerable evidence that the extra 7 are not entirely responsible for the differences between *vulgare* and durum or emmer varieties. In the homologous 14 group there must be some factor differences and through the process of segregation certain of these factors from the durum or emmer parent can be transferred to types possessing 42 chromosomes. It also seems unreasonable to expect that groups of characters or those single characters dependent upon several factors may be transferred easily. It is logical to expect that rust resistance may be transferred and this is borne out by genetic experiments.

Inheritance of Rust Resistance in Interspecies Crosses

In three cases it has been definitely proved that rust resistance can be transferred from the 28 to the 42 chromosome group. In two well known papers Hayes, Parker and Kurtzweil (*8*), and Hayes, Stakman, and Aamodt (*9*) it was shown that rust resistance had been transferred in a cross of the durum wheat Iumillo with Marquis, to a common wheat. This cross resulted in the production of the variety Marquillo which is highly rust resistant, has 42 chromosomes and is distinctly a *vulgare* type.

From a cross between Yaroslav Emmer and Marquis, McFadden (*14*) obtained the two strains H-44-24 and Hope which are very highly rust resistant and are of the common wheat type. These wheats are practically immune under field conditions and constitute one of the most decided advances in rust breeding work.

At the Dominion Rust Research Laboratory a cross was made in 1925 between Marquis and a durum wheat known as Pentad which is highly rust resistant but of very little commercial value. A hybrid has been produced from this cross which possesses the Pentad type of resistance in the field and is a beardless *vulgare* wheat.

These three are outstanding examples of the transfer of rust resistance from one wheat species to another with a higher chromosome number. The actual ratios obtained are very complicated owing to irregularities in chromosome behaviour and indicate very little with respect to the factorial basis of resistance in such crosses. The fundamental point however is that, as indicated in the first place by the cytological evidence, the resistance can be transferred, and this provides a very firm foundation for practical breeding operations. Evidently the initial step and the most difficult one is the making of interspecific crosses in order to obtain resistance in *vulgare* wheats. These may then be made use of in further crosses in order to combine resistance with quality and other desirable agronomic characters.

Breeding for Resistance to Specific Physiologic Forms of Stem Rust

Aamodt (*2*) has pointed out in an excellent review of the rust breeding work that a great difficulty encountered in the early investigations was the failure of some varieties and new productions to maintain their resistance from year to year and in different localities. This phenomenon was fully explained by the discovery by Stakman and Piemeisel (*23*) in 1917 of the existance of physiologic forms of *Puccinia graminis tritici*. It was evident that most varieties were resistant to certain forms only, and if other forms

appeared in different years or localities the varieties would be susceptible. The collection, identification, and culture of these forms, has been going on continuously since their discovery and reports have been given from time to time by Stakman and Levine (*24*), Newton (*16*), Newton and Johnson (*17*), Newton, Johnson and Brown (*19, 20*), and Levine (*13*). These reports show that we now have approximately 50 forms of wheat stem rust all of which have to be contended with in the breeding program.

The next step in fundamental investigation was therefore the determination of the mode of inheritance in wheat crosses of resistance to particular physiologic forms. Numerous crosses were made. Aamodt (*2*) summarizes the results of these studies as follows—"This evidence as well as that from extensive breeding studies conducted under field conditions substantiates the belief that it is entirely possible to produce a bread wheat resistant to all of the known physiologic forms of rust." In every case it was found that the reactions of the parent varieties to particular physiologic forms could be placed on a definite factor basis—that the resistance of one variety could be combined with the agronomic characters of another variety or that the resistance of two varieties to different physiologic forms could be combined in one variety. Of particular interest from this standpoint is the inheritance of resistance to groups of physiologic forms. The reactions of varieties to such groups of forms are frequently controlled by the same genetic factors. For example Kanred wheat is immune to 11 physiologic forms and it was demonstrated by Aamodt (*1*) that this immunity to 11 forms is controlled by a single genetic factor. In 1928, Goulden, Neatby and Welsh, (*6*) studied a similar relationship in an H-44-24 × Marquis cross and found that the moderate resistance of H-44-24 in the seedling stage to at least five forms was controlled by the same genetic factors. These are allelomorphic to factors in Marquis which gave susceptibility to four of the forms and high resistance to the other. Obviously this mode of inheritance greatly simplifies the breeding problem. Extensive experiments are now being conducted at the Dominion Rust Research Laboratory in order to determine the genetic basis of rust resistance in as many varieties as possible. A complete knowledge of this subject will enable the plant breeders to make appropriate crosses for building up resistance to all of the known physiologic forms.

An important development in our knowledge of the rust problem has come through a study of mutations in physiologic forms and the discovery of heterothallism in the rust organism. Newton and Johnson (*18*) discovered very distinct color mutations in two common physiologic forms. There was very little evidence of a corresponding change in pathogenicity as the forms remained practically the same in their reactions on the differential host varieties, but the fact of mutability is a general indication that changes in pathogenicity may occur and if so the number of forms may be subject to a gradual increase. However we have no direct evidence of this as yet so it does not seem likely that a sufficient number of new forms will arise to interfere seriously with the breeding program. Of distinctly great importance however was the discovery by Craigie (*4, 5*) of heterothallism and the function of the pycnia in the life cycle of the rusts. It was clearly shown that a mechanism exists for crosses between different forms while on the barberry bush and consequently for the production by hybridization of

entirely new forms. Speculating as to the possibilities here we must appreciate first that the forms are quite well mixed in their occurrence throughout the rust area and also in the infections on barberry bushes. It seems likely therefore that most of the possible combinations through hybridization now exist and that new forms can only occur when they arise by mutation and begin to hybridize with some or all of the others. As stated above new mutant forms are not likely to occur frequently but one new mutant form by hybridization with the old ones would result in the production of several distinctly new forms.

Mature Plant Resistance

The alarming possibilities from the production of new forms of rust are very largely offset by the knowledge that a type of resistance exists in some varieties of wheat which seems to apply equally under field conditions to all forms.

It was observed at the Minnesota Experiment Station that some varieties such as Acme, Kota, Velvet Don, and Pentad were quite susceptible to a number of physiologic forms in the seedling stage but were uniformly resistant from place to place and from year to year when grown in the field. It seemed likely that some development took place in the plant as it approached maturity which was responsible for the resistance exhibited at the heading stage. Hursh (*10*) obtained some evidence that this resistance was morphological in nature. This would explain of course why the particular type of resistance should appear to apply equally to all forms of rust. Hayes et al (*9*) in a cross of (Marquis × Iumillo) with (Marquis × Kanred) came to the conclusion that the genetic factors for the resistance of the (Marquis × Iumillo) parent under field conditions were inherited apparently independently from the factors for immunity from certain physiologic forms in the seedling stage. This indicated that the two types were distinct and such a conclusion is amply borne out by the results from two crosses made at the Rust Research Laboratory. The first of these is the H-44-24 × Marquis cross which was reported on in 1928 by Goulden, Neatby and Welsh (*6*). The H-44-24 parent was found to be resistant in the seedling stage to two groups of forms including 21 and 36. All lines of the F_3 generation were tested to these two forms and their reactions were compared with those obtained in the field. The results are best shown in summary form by comparing the field reactions of lines breeding true for seedling resistance with lines breeding true for seedling susceptibility. This is shown in table 2.

Table 2. *Two by three fold contingency table summarizing field reactions of lines homozygous resistant, and homozygous susceptible in the seedling stage.*

Seedling reaction \ Field reaction	Homozygous Resistant	Segregating	Homozygous Susceptible	Totals
Resistant to forms 36, 21	8	18	10	36
Susceptible to forms 36, 21	6	18	8	32
Totals	14	36	18	68

$\chi^2 = 0.275$ P = .90 to .80

Here we note that in both groups according to seedling reaction there is a 1 : 2 : 1 ratio in the field of resistant, segregating, and susceptible lines. This proves that the segregation for field reaction is quite independent of the seedling reaction. The same result is illustrated in figures 1 and 2. In figure 1 are shown the seedling reactions of three strains from H-44-24 × Marquis to form 36 and in figure 2 we have the field reactions of the same strains where form 36 was undoubtedly present.

Figure 1. Seedling reactions of three F_3 lines from H-44-24 × Marquis to form 36.

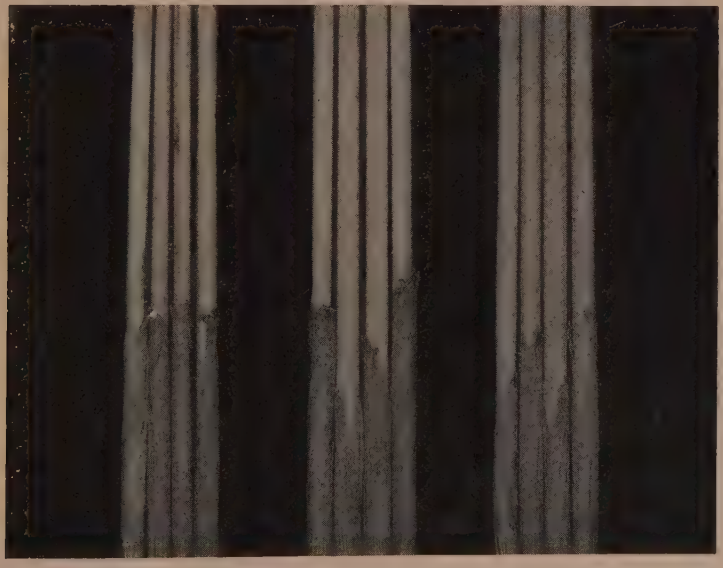

Figure 2. Field reactions of the same three lines illustrated in figure 1.

A result similar to the above has been obtained recently in a Pentad × Marquis cross. The seedling reactions of these two varieties are shown in table 3 as taken from Newton, Johnson and Brown (*19*). Marquis, it will be observed, is susceptible in the seedling stage to most of the forms and it is well known that Marquis is susceptible in the field. Pentad, while highly resistant to a number of forms in the seeding stage, is also fairly susceptible to such forms as 21, 27, 34, 53, and 57. Of these form 21 at least is quite common but Pentad is always highly resistant in the field. It appears, therefore, to possess a high degree of mature plant resistance.

The cross was made in 1925 and from the F_2 grown in 1926 16 plants were saved which were resistant and chiefly of the *vulgare* type. Among the F_3 lines 3 bred true for resistance while two lines segregated according to a 3 : 1 ratio of resistant to susceptible plants. These ratios are given in table 4.

TABLE 3. *Seedling reactions of Marquis and Pentad to 22 physiologic forms.*

	Physiologic forms										
	9	14	15	16	...17	19	21	27	29	30	32
Marquis	4—	2—	4—	2=	4—	2—	4	2	4—	4	4=
Pentad	3—	3±	2±	3+	3±c	3±c	3±	4	0;	0;	0;
	33	34	35	36	38	48	49	50	52	53	57
Marquis	2	4—	4=	4	2=	1	4—	2—	4	2±	4
Pentad	x—	4	x±	0;	1±	0;	x	1+	0;	3+	3+

TABLE 4. *Segregation in the field for resistance and susceptibility of two F_3 lines of Marquis × Pentad.*

Line number	Number of Plants Resistant	Susceptible	Total	X2	P
C—25—F_3—2	125	39	164	.1301	.70
C—25—F_3—8	106	25	131	2.4453	.10
Total	231	64	295	2.5754	.30

The table also shows the values of χ^2 and P for the individual ratios and for both ratios considered together. It is evident that the fit to a 3 : 1 ratio is reasonably good, and indicates that the two F_2 plants giving rise to these F_3 families were heterozygous for a single factor pair.

In order to determine the relation in this cross between seedling and field resistance the progeny of the 125 resistant plants from line C-25-F_3-2 were tested in the seedling stage to form 36 to which Pentad is highly resistant. All of the progenies proved uniformly *susceptible*. In order to obtain additional data on this phase a study was made of a random sample of 12 F_4 lines. These were grown from the 125 resistant plants obtained in 1926 from line C-25-F_3-2, and their progenies were tested in the seedling stage to four forms, 48, 14, 52, and 36. To form 14, Marquis is resistant and Pentad susceptible. To forms 52 and 36, Marquis is susceptible and Pentad highly resistant. To form 48 both varieties are resistant. The results from these tests are given in table 5.

The result is quite striking. It shows that the 12 lines which are uniformly resistant in the field appear to have the Marquis factors for rust reaction in the seedling stage. There is no trace of the Pentad factors for seedling resistance.

TABLE 5. *Seedling reactions to forms 48, 14, 52, and 36 of twelve F_5 lines of Pentad × Marquis which are highly resistant in the field.*

Line No.	Reactions to Physiologic Forms			
	48	14	52	36
1322	1+	1+	4+	4
1324	1+	1—	4+	4
1326	2—	1	4+	4
1335	2—	1±	4+	4
1342	1+	1+	4+	3+
1344	2	2—	4+	3+
1347	1	1	4	4
1350	1	2—	4	3+
1352	2—	1	4—	4
1354	1+	1	4	3+
1355	2—	1	4	3+
1358	1	1	4	3+

This result in addition to the data from the H-44-24 × Marquis cross establishes beyond doubt the independence in inheritance of mature plant and seedling resistance. It is also of great interest to note in both cases that the inheritance of mature plant resistance is very simple. Resistance is dominant in the F_1 and in the F_2 there is a clear cut 3 : 1 segregation of resistant to susceptible plants. In the F_3 generation therefore it is possible to obtain lines true breeding for rust resistance equal to one-quarter of the number of F_2 plants grown. This means that large numbers of resistant strains can be produced at will from which a rigid selection can be made of those possessing desirable agronomic characters and good milling quality. The inheritance of seedling resistance is much more complicated and since there are no varieties of *vulgare* resistant to the whole group of forms, the process of building up complete resistance by repeated crosses would be enormous.

It remains only to consider the nature of mature plant resistance and whether or not it will meet the requirements in the production of a rust resistant wheat. In the first place is it likely to continue to apply to all of the physiologic forms? Previous mention has been made of the variety Velvet Don which according to Aamodt (*2*) has been highly resistant in the rust nursery at University Farm, Minnesota, for 18 years. This variety was found to be susceptible in the seedling stage to 11 common physiologic forms so that it undoubtedly possesses a mature plant type of resistance. During the 18 years in the rust nursery at University Farm rust forms were used which were collected from all over the wheat growing area of the North-west so that forms to which Velvet Don is susceptible in the seedling stage must certainly have been present. The same is true of Acme wheat which has never been known to show an appreciable amount of rust in the field and yet in the seedling stage it is susceptible to every form to which it has been tested. The Marquis × Emmer lines, H-44-24 and Hope produced by Mr. McFadden are repeating the performance of Velvet Don and Acme. While susceptible to a number of forms in the seedling stage they are practically immune in the field. Clark and Ausemus (*3*) studied the field reactions of Hope wheat in a number of crosses with susceptible and partially resistant wheats and made the following statement: "It seems certain that most wheat breeding for rust control in the immediate future will be for rust immunity, using Hope or related strains as the immune parent."

The only possible difficulty with respect to mature plant resistance would appear to be its association with certain undesirable characters. In the H-44-24 × Marquis cross mentioned above it was found that the *susceptibility* of H-44-24 to black chaff was closely linked with *resistance* to rust. This of course may be a genetic linkage—in fact the results to date, Goulden, and Neatby (*7*), indicate that this is the case and that the two characters may be separated by growing sufficiently large populations. Other characters such as weakness of straw seem to be associated with mature plant resistance but here again the linkage seems to be genetic. A number of lines have been selected which possess high resistance and satisfactorily strong straw.

Summary

1. Fundamental investigations bearing on the practical problem of breeding rust resistant varieties of wheat are reviewed briefly.
2. Cytological studies including chromosome counts and chromosome behaviour in interspecific crosses show that it is logical to expect that certain characters such as rust resistance can be transferred from the 28 to the 42 chromosome group.
3. In three distinct cases rust resistance has been transferred in practical experiments from emmers and durums to common wheats.
4. The discovery of physiologic specialization in *Puccinia graminis tritici* explained the lack of uniformty in varietal trials for rust resistance. These studies have been continued and show that we now have at least 50 distinct forms all of which must be taken into consideration in the breeding program.
5. Color mutations in physiologic forms of stem rust and the discovery of heterothallism are indications that the number of physiologic forms may increase indefinitely by natural processes.
6. Mature plant resistance exhibited by certain rust resistant varieties appears to apply equally to all of the known forms of rust. Its existence very largely offsets the alarming possibilities through natural increases in the number of physiologic forms.
7. The inheritance of mature plant resistance is entirely independent of seedling resistance and is very simple in nature. It offers much greater possibilities in the production of resistant varieties than the building up of seedling resistance by a complicated series of crosses.

Acknowledgements

To Mr. K. W. Neatby, Cereal Specialist, thanks are due for invaluable assistance rendered in the studies on the inheritance of mature plant resistance.

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LITERATURE CITED

1. Aamodt, O. S. The inheritance of growth habit and resistance to stem rust in a cross between two varieties of common wheat. Jour. Agr. Res. *24*: 457-470, 1923.
2. ———————. Breeding wheat for resistance to physiologic forms of stem rust. Jour. Amer. Soc. Agron. *19*: 206-218, 1927.
3. Clark, J. A. and E. R. Ausemus. Immunity of Hope wheat from black stem rust inherited as a dominant character. Jour. Amer. Soc. Agron. *20*: 152-159, 1928.
4. Craigie, J. H. Experiments on sex in rust fungi. Nature, July 23, 1927.

5. ————————. Discovery of the function of the pycnia of the rust fungi. Nature, November 26, 1927.
6. Goulden, C. H., K. W. Neatby, and J. N. Welsh. The inheritance of resistance to *Puccinia graminis tritici* in a cross between two varieties of *Triticum vulgare*. Phytopath. *18*: 631-658, 1928.
7. ————————., and K. W. Neatby. A study of disease resistance and other varietal characters of wheat—Application of the analysis of variance and correlation. Sci. Agr. *9*: 575-586, 1929.
8. Hayes, H. K., J. H. Parker, and C. Kurtzweil. Genetics of rust resistance in crosses of varieties of *Triticum vulgare* with varieties of *T. durum* and *T. dicoccum*. Jour. Agr. Res. *19*: 523-542, 1920.
9. ————————., E. C. Stakman and O. S. Aamodt. Inheritance in wheat of resistance to black stem rust. Phytopath. *15*: 371-387, 1925.
10. Hursh, C. R. Morphological and physiological studies on the resistance of wheat to *Puccinia graminis tritici* Erikss. & Henn. Jour. Agr. Res. *27*: 381-412, 1924.
11. Kihara, Hitoshi. Uber cytologische studien bei einigen Getreidearten. Bot. Mag. Tokyo. *32*: 17-38, 1919.
12. ————————. Über cytologische studien bei einigen Getreidearten. III Uber die Schwankungen der chromosomenzahl bei den Speciesbasterden, der Triticum-Arten. Bot. Mag. Tokyo. *35*: 19-44, 1921.
13. Levine, M. N. Biometrical studies on the variation of physiologic forms of *Puccinia graminis tritici* and the effects of ecological factors on the susceptibility of wheat varieties. Phytopath. *18*: 7-123, 1928.
14. McFadden, E. S. "Synthetic" rust proof bread wheats. Dakota Farmer. *45*: 102-1925.
15. Melburn, C. Myrtle and W. P. Thompson. The cytology of a tetraploid wheat hybrid, *Triticum spelta* × *Triticum monococcum*. Amer. Jour. Bot. *14*: 327-333, 1927.
16. Newton, Margaret. Studies in wheat stem rust. Trans. Roy. Soc. Can. *16*: 1922.
17. ————————, and T. Johnson. Physiologic forms of wheat stem rust in Western Canada.
Greenhouse experiments on the relative susceptibility of spring wheat varieties to seven physiologic forms of wheat stem rust. Sci. Agr. *7*: 4-11, 1927.
18. ————————, and T. Johnson. Color mutations in *Puccinia graminis tritici*. Phytopath. *17*: 711-725, 1927.
19. ————————, T. Johnson, and A. M. Brown. New physiologic forms of *Puccinia graminis tritici*. Sci. Agr. *9*: 4, 1928.
20. ————————, T. Johnson, and A. M. Brown. Reactions of wheat varieties in the seedling stage to physiologic forms of *Puccinia graminis tritici*. Sci. Agr. *9*: 10, 1929.
21. Sakamura, Tetsu. Kurze Mitteilung über die chromosomenzahlen und die verwandtschaftsverhaltnisse. Bot. Mag. Tokyo. *32*: 150-153, 1918.
22. Sax, Karl. Chromosome behaviour in Triticum hybrids. Zeit für. Ind. Abstamm. und Vererb. Supplement Vol. II. 1267-1283, 1928.
23. Stakman, E. C. and F. J. Piemeisel. A new strain of *Puccinia graminis*. Abstract in Phytogath. *7*: 73, 1917.
24. ————————. and M. N. Levine. The determination of biologic forms of *Puccinia graminis*. Jour. Agr. Res. *15*: 221-250, 1918.
25. Thompson, W. P. The correlation of characters in hybrids of *Triticum durum* and *Triticum vulgare*. Genetics *10*: 285-304, 1925.
26. ————————. Chromosome behaviour in triploid wheat hybrids. Jour. Genetics *17*: 43-48, 1926.
27. ————————. Characters of common wheat in plants with fourteen chromosomes. Trans. Roy. Soc. Can. Sec. V. 1927.
28 ————————. Cytology of species hybrids in wheat. Sci. Agr. *8*: 56-62, 1927.
29. ————————. and Lillian Hollingshead. Preponderance of Dicoccum-like characters in hybrids between *Triticum dicoccum* and *Triticum vulgare*. Jour. Genetics *17*: 283-307, 1927.
30. Watkins, A. E. Genetic and cytological studies in wheat I. Jour. Genetics. *14*: 129-171, 1924.
31. ————————. Genetic and cytological studies in wheat II. Jour. Genetics. *15*: 313-366, 1925.
32. ————————. Genetic and cytological studies in wheat III. Jour. Genetics. *18*: 375-396, 1927.
33. ————————. Genetic and cytological studies in wheat. Jour. Genetics. *19*: 81-96, 1927.
34. ————————. The genetics of wheat species crosses. I. Jour. Genetics. *20*: 1-26, 1928.

COMPETITION AT THE FEED TROUGH—A FACTOR IN GROUP FEEDING OF PIGS

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For the past two years this station has been studying the variation in rates of growth and fattening found between animals on feeding trials, and from the data collected, have come to light, somewhat incidental to the main problem, some very interesting and perhaps significant items bearing on the practical side of pig feeding. One of the most striking concerns the economy of gains made by "slow doing" pigs.

It was necessary as a part of this trial to feed and house ten pigs individually and to record individually the feed consumed and gains made. Among this group were two which from the start were "poor doers" as compared to the other eight. These two pigs weighed, at the opening of the trial, 23 and 25 lbs. respectively as compared to the average weight of the other eight of 33 lbs. The heaviest pig of the eight weighed 42 lbs. and the smallest 27 lbs. Since each pig had its own pen and own feed trough the factor of competition at the feed trough and its relation to size of pig was non-operative.

The pigs were weighed at 10 day intervals and feed eaten during the corresponding periods recorded. From these data the gains of each pig per 100 lbs. dry feed were calculated. Thus over the entire feeding period of 120 days it was possible to follow the progress of each pig as well as the average results of the ten.

As already stated, two pigs were spotted at the start as "slow doers" and at one time it was feared that they would have to be replaced by better prospects. Their average gains and those of the eight others are shown in table 1.

TABLE 1. *Average gains in liveweight.*

Days on Feed	Two Slow Doers	Eight Others
10 days	7.5 lbs.	10.4 lbs.
20 "	13.5	20.2
30 "	23.5	33.3
40 "	34.0	42.0
50 "	43.5	62.8
60 "	63.5	79.5
90 "	112.5	132.8
120 "	173.5	196.0

From the above it will be seen that for the first 50 days of feeding these "tail enders" were not making satisfactory growth as compared to the others.

Now the question arises—why didn't they grow as fast as the others? All ten were littermates, hence of like breeding and age. Undoubtedly there is more than a single factor involved in the rate of growth enjoyed by any given pig. But, given equal freedom from the drag of disease or of parasites and with feed of like composition there is, from the study thus far made of the question, evidence to support the theory that a close relationship exists between gains realized and the quantity of feed eaten over the corresponding period.

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The data quite definitely suggest that differences in appetites, controlling as they do, in the absence of the factor of competition at the trough, the amounts of feed actually eaten, explain to a large extent the differences in rate of growth realized. The causes of differences in appetite we do not attempt to account for. If this is true, then obviously rate of gain alone does not determine the economy of such gains. It is the gain made in connection with a given quantity of feed eaten that is of real importance. (Length of feeding period may, in some cases, be a minor factor in total cost of gains).

This side of the story is told by the figures in table 2.

TABLE 2. *Gains per 100 lbs. feed eaten.*

Days on feed	Av. two slow doers	Av. eight others
10 days	42 lbs.	45.6
20 "	34	36.4
30 "	34	35.5
40 "	34.5	33.4
50 "	29	33.8
60 "	31	32.3
90 "	24.5	24.4
120 "	26	27.5

A little study of the data in table 2 makes it clear that our two slow growing pigs made just about as efficient use of the feed they actually ate as did their littermates. By the end of the four-month feeding period there was little difference in the rate of gain *when the amount of feed eaten is considered.* It must be remembered that the showing made by these two pigs discussed was made under conditions much more favourable to them than would have been the case had they had to fight for their share of the rations. What would have happened if these two pigs that were obviously not possessed of ravenous appetites, had shared a pen and feeding trough with their littermates?

In a comparative group in this same experiment were ten pigs of similar age to those individually-fed; carried on the same kind of feed; but housed and fed as a group in one pen. In this group-fed lot there were also two "slow doing" pigs. Their progress in comparison to that of the two in the individually-fed lot is interesting.

One of this pair died before the end of the first 10-day period. Why was not learned. For the two or three days previous, however, he was driven from the trough by the more greedy and stronger pigs.

The other managed to last out the full feeding period of some 120 days. His gains and average of those of the eight others of the group were as follows:

TABLE 3. *Gains in liveweight (group fed).*

Days fed	One slow doer	Eight pen mates
10 days	8 lbs.	12.6 lbs.
20 "	12	23.6
30 "	17	38.0
40 "	25	51.1
50 "	33	70.8
60 "	35	79.5
90 "	50	125.0
120 "	86	176.3

Before these two sets of figures are compared the quantities of feed consumed by the two comparative lots should be noted. They appear in table 4.

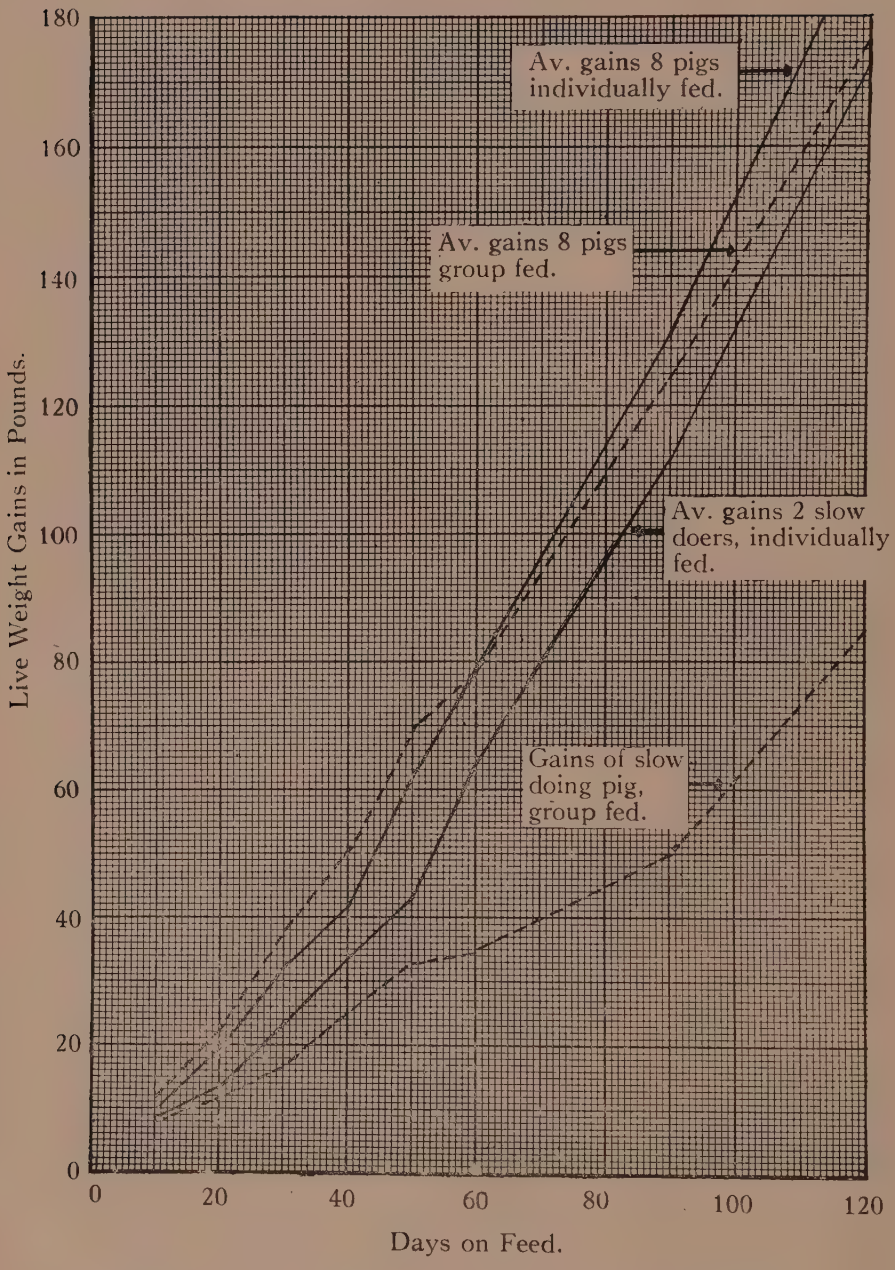

Chart 1. Effect of group feeding on gains of slow-doing pigs.

TABLE 4. *Total feed eaten.*

No. days	10 Individually Fed Pigs		9 Group Fed Pigs	
	Total	Average per pig	Total	Average per pig
10 days	228 lbs.	22.8 lbs.	280 lbs.	28.5 lbs.
20 "	520	52.0	561	62.3
30 "	876	87.6	938	104.2
40 "	1261	126.1	1323	147.0
50 "	1776	177.6	1809	201.0
60 "	2379	237.9	2299	255.5
90 "	4915	491.5	3893	432.6
120 "	7035	703.5	5940	660.0

It will be seen from table 4 that for the first sixty days the group-fed pigs consumed more feed per pig than did those individually-fed. Hence it was not because of a shortage of feed that their gains were slower.

Past the two months period the feed eaten by the group-fed lot dropped below that of Lot I. This is explained, at least in part, by the exceedingly small quantities eaten by the slow doing pig—the effect of this condition becoming more marked as the feeding period advanced and the daily feed consumption of the others increased with their increasing live weight.

Naturally as the better feeders got larger they made it more and more difficult for the smaller pig to get his share of feed. For the last month of feeding it was apparent to even the casual observer that he was allowed to feed only after the others had satisfied their appetites and then there was little if anything left. He got so timid that he would not stay near the trough while the others were feeding.

The progress of this pig as compared to the "slow doers" in the individually-fed lot is shown in Chart 1.

From this chart we see that whereas the progress of the "slow doers" among the individually fed pigs changed after about 60 days from poor to practically the same as their lot mates, that of the runt who had to meet the competition of his pen mates for his feed became worse as the feeding period continued.

CONCLUSIONS

There are obviously three conclusions which may be drawn tentatively from the above data:

1. That, other factors being equal, gains by pigs in live weight are closely related to the quantities of feed eaten.
2. That slow feeders, when not hindered by competition at the feed trough, may recover from their initial slow progress and feed quite as well as those getting away to a better start.
3. That the slow feeders should not be penned and fed with larger more greedy pigs. Size rather than age should determine the groupings.

INHERITANCE OF COLOUR IN ASTERS*

A Preliminary Report

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Several of the large seed houses in Great Britain make use of a knowledge of the order of dominance of colour in flowers to keep a check on growers producing flower seed under contract for them. The presence of rogues of a higher grade of dominance in any stock is taken to indicate carelessness on the part of the grower or else that natural crossing takes place. Carelessness cannot be tolerated on the part of any grower as these seed houses cater to a very discriminating trade.

Some of the leading growers in British Columbia are now making use of the order of dominance of colour to aid them in rogueing their seed plots.

A request was received for the order of dominance of colour in asters. A correspondence survey of the field showed that no information had been published on this subject and it was decided to undertake definite breeding tests to obtain this information.

Plan of Procedure

A foundation plot was set out in 1926 containing ninety-five strains. Eleven plants of each strain were planted from seed obtained from several different commercial seed firms. Rows were three feet apart and plants 18 inches apart in the row.

Many rogues were observed. The seed of each of these was harvested separately. At the same time seed was saved from a plant true to type and colour of the parent stock.

Thus a series of colour pairs was obtained and progeny tests made with each pair. By comparison of colour pairs an order of dominance of colour has been worked out. The following colour pairs have been tested:

Rogue	Parent	Type	Serial Number
Violet	Red Purple	Queen of Market	70
Purple	Pink	Early Wonder	20
Purple	Pink	Astermum	23
Violet	Bright Rose	Queen of Market	69
Pink	White	Imperial	1
Pink	White	Queen of Market	67
Pink	White	Imperial	15
An unfixed blue containing white, pink, purple and lavender.		Imperial Bluebird	17

It is generally believed by aster growers that little natural crossing takes place and the trial plots were planted close together. In two years' trials

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a noticeable amount of natural crossing, approximately 10 per cent each year, took place, and this materially affected the results.

The results obtained are shown in table 1, the columns showing the year planted, the serial number in the plots, the variety and colour of original parent and the colour of the rogue from it, tested, the number tested, and the number of each colour obtained in the progeny.

TABLE 1. *Progeny tests of colour pairs of asters at the Dominion Experimental Station, Summerland, B.C.*

Year Tested	Serial Number	Variety or strain tested with colour of stock selected	Number tested	Dark purple	Med. purple	Light purple	Violet	Red purple	Lavender	Lilac	Light red	Dark pink	Flesh pink	Shell pink	Red and white	White
1926	70	Queen of Market Purple	12	1		4	5			2						
1927	70-1	Violet Strain of 70	11		3	4		2		2						
1928		Red purple strain of 70-1	44	1		4		39								
1926	20	Early Wonder Pink	11									11				
1927	20-5	Pink Strain of 20	21			3						18				
1928		Purple Rogues in 20-5	62			36				1		13				12
1928		Pink Strain in 20-5	22									22				
1926	23	Astermum Pink	11									11				
1927	23-1	Pink Strain of 23	11		3							8				
1928		Purple Rogue in 23-1	65		43							22				
1928		Pink Strain of 23-1	174		15						3	156				
1926	69	Queen of Market Pink	11									11				
1927	69-1	Pink Strain of 69	22			1	1					20				
1928		Purple Rogue in 69-1	20			17						3				
1928		Violet Rogue in 69-1	21				17					4				
1926	1	Imperial Giant Purity White	11													11
1927	1-1	White Strain of 1	22									1				21
1928		Pink Rogue in 1-1	22			1						16				5
1928		White Strain of 1-1	15			3			1			5				6
1926	67	Queen of Market White	11													11
1927	67-1	White Strain of 67	22									1				21
1928		Pink Rogue in 67-1	22			1						17			2	2
1926	15	Imperial Flesh Pink	8									1		5		2
1927	15-1	Deep Pink Rogue in 15	21									12	2			7
1928		Flesh Strains of 15-1	22			1						4	13			4
1928		Deep Pink Strains of 15-1	88			10						46	17			15
1928		White Strains of 15-1	98			4						2	1			91
1926	17	Imperial Bluebird	11	1		5				2						3
1927	17-4	Lilac Strain of 17	11			4				2						5
1928		Light purple Strains of 17-4	87			62				18		2				5
1928		Lilac Strain of 17-4	44			1			3	28		5				7
1928		White Strain of 17-4	108			4			6	10		11				77
1927	17-8	White Strain of 17	11			7										4
1928		Purple Strains of 17-8	151			117				3						31
1928		White Strains of 17-8	63			2						1				60
		Summary White Strains of 17	170			5			6	10		12				137
		" Purple " " 17	238			179				21		2				36
		" Lilac " " 17	42			1			3	28		3				7

The progeny of #70 suggests natural crossing rather than dominance of red purple, although the number tested is too small for definite conclusion.

The progeny of #20 segregated along mendelian lines. The original pink plant was evidently crossed with a heterozygous purple carrying a white strain. A check test of a pink gave a pure pink. This is further proof of crossing. Purple is dominant to pink and white.

The progeny of #23 again showed purple dominant to pink and further proof of natural crossing influencing the results is shown in the occurrence of 3 light reds in a pink strain. Similar light reds were grown in an adjoining row the previous season.

Violet and Purple are both dominant to pink in the progeny of #69.

Pink is dominant to white in the progeny of #67. A white, true in 1926, was crossed that season with a pink which appeared as a dominant in 1927, and segregated into pink and white in 1928. A purple rogue indicates further crossing in 1927.

Deep pink appears to be dominant to flesh pink and shell pink. Some pinks darken with age from shell pink into deep pink. Others fade from flesh or shell to white. These probably behave differently genetically in the progeny of #15.

There is no true blue aster. The so-called blue #17 was evidently produced by hybridizing purple, lavender, pink, and white.

Discussion

A study of the chemical composition of flower pigments may aid in a study of inheritance of colour in flowers. The colouring matter of flowers is due to *anthocyanins* and plastid pigments (*1*). No true yellow occurs in asters (*2*). Therefore the colour is due to *anthocyanins*. Asters contain two pigments, asterin and callistephin (*3*); the asterin, however, has recently been shown to be identical with chrysanthemin (*4*). The same pigment may exist in a flower in different forms, as in the cornflower, *centaurea cyanus* (*5*), there is a purple pigment, cyanin, which is itself a free acid. a blue pigment which is the potassium salt of the purple pigment, and a red pigment which is the oxonium salt of the purple with some organic acid. According to Willstatter (*6*) the variation in shades of the same colour depends largely up on the presence of acids, alkalies, salts, etc., in the cell sap. Haas and Hill (*7*) attribute the varying shades partially to the configuration of the anthocyanin concerned and partly to the reaction of the cell sap. Colour would appear to act as an indicator in the plant itself, showing whether the cell sap is neutral, acid or alkaline. This might explain the peculiar behavior of the purples in the progeny of #70.

According to Haas and Hill (*8*)"the appearance of anthocyanin seemingly depends upon the immediate metabolic condition of the plant and in some cases may be sporadic, while in other instances it is characteristic of the species or variety or form." Further, the same authors say (*9*) "The amount of pigment produced depends on the relative activities of the oxidizing and reducing agents. If the former be the more potent, a coloured substance will be formed, but if the latter be dominant, no pigment will appear." This may throw some light on the behaviour of the whites in the progeny of

Imperial Bluebird. Punnett (*10*) has shown that colour in sweet peas is due to the interaction of two factors both of which must be present or colour cannot appear. According to Onslow (*11*), the two whites which when crossed produce colour in Lathyrus, contain the components of anthocyanin. Cuthbertson (*12*) points out the relationship between colour of the axil (due to anthocyanin) and colour of bloom in 68 varieties of sweet peas. In asters a similar relationship occurs between the presence of anthocyanin in the stem and the colour of the bloom. The strongly pigmented blooms usually have stems showing more or less pigmentation. R. J. Anderson (*13*) claims that in a cross between American and European varieties of grapes, the pigment of the European grape is inherited by the hybrid.

In 1927 purples appeared 26 times in 236 tests of strains that were true in 1926 and showed no purple. This amounts to 11.01 per cent. In 1928, purples appeared 45 times in 469 tests of strains that had shown no purples in two previous tests. This amounts to 9.6 per cent. The appearance of light reds in the progeny of #23, indicates crossing. The progeny of the rogues that appeared in 1927 in strains that were true in 1926 broke up in 1928, showing in the majority of cases a mendelian segregation of the two parents and in other cases evidences of the fact that the crossing parent was heterozygous for one or more additional colours. Therefore, it may safely be assumed that considerable natural crossing occurs, approximately 10 per cent of an average of two years' tests. .

Conclusion

Granted that such natural crossing does take place and the unexpected appearance of "outside" colours is thereby explained, the relation of the various colours would appear to be as follows: White is near the bottom of the range, while purple is at the top, and the reds are in the middle. Blues would go over the reds if blue purple is dominant to red purple. Deep pink is dominant to white, but the relation of flesh pink or shell pink to white is not yet settled.

BIBLIOGRAPHY

1. Onslow, Muriel Wheldale: The Anthocyanin Pigments of Plants, Page 3.
2. Bailey, L. H.: Cyclopedia of Horticulture, Vol. *2*, Page 63.
3. Willstatter and Burdick: Liebigs Annalen du Chemie, Liepsig 1916 CCCCXII, Page 149-164.
4. Willstatter and Robinson: Berichte 1928-61B-2503.
5. Willstatter and Everest: Liebigs Annalen du Chemie, Liepzig, 1913, CCCCI, Page 189-232.
6. Willstatter: The Anthocyanin Pigments of Plants (Onslow), Page 69.
7. Haas and Hill: An introduction to the chemistry of Plant Products, Vol. *1*, Page 340.
8. Haas and Hill: An Introduction to the Chemistry of Plant Products, Vol. *1*, Page 343.
9. Haas and Hill: An Introduction to the Chemistry of Plant Products, Vol. *1*, Page 350.
10. Punnett, R.C.: Mendelism, Page 41. Macmillan Company, New York.
11. Onslow, Muriel Wheldale: The Anthocyanin Pigments of Plants, Page 19.
12. Cuthbertson, Wm.: The Sweet Pea Annual (National Sweet Pea Society, 1915).
13. Anderson, R. J.: Chemical studies of grape pigments, Technical Bulletin 146, Geneva, New York, 1928, Page 13-15.

EDUCATION IN AGRICULTURE FOR ADULTS AS OFFERED BY THE UNIVERSITY OF SASKATCHEWAN*

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Little requires to be said of the field for education in agriculture in Saskatchewan or of its importance. Of a total population of 820,738 persons—1926 census—578,206 are living on farms and, furthermore, the great majority of those not living on the land are dependent upon the success of agriculture for their livelihood. Saskatchewan agriculture, notwithstanding the importance it has attained, is still in its infancy; methods and practices are changing; experience and experiment are disclosing weaknesses and establishing principles and every means must be employed to disseminate the latest information. The fact that new settlers are constantly being assimilated also creates an additional demand for instruction.

Practically all adult education in agriculture offered by the University of Saskatchewan is carried on by the Department of Agricultural Extension and most of it is extra-mural in character. Certain intra-mural short-term courses are offered annually but the major problem is to serve those actually living on the 117,000 farms of the province, who cannot, for various reasons, come to the University for instruction. Almost invariably this service is organized and carried on through community agricultural organizations, mostly agricultural societies, which societies now number 162 with over 30,000 members and a program which reaches three or four times that number.

The few intra-mural courses offered treat with such subjects as the operation and care of gas engines, the operation of threshing machines and combines, butter-making, bee-keeping, poultry and blacksmithing. What is known as the Annual Ten-Day Farm School has recently been added to the list. The extensive use of gasoline power in Saskatchewan has created a need for the engineering courses. They are patronized largely by young farmers and farmers' sons. The Farm School, which constitutes an effort to give in a short period the latest information on farm questions in general, is supported mainly by older farmers. This school is steadily gaining in favor.

Extra-mural instruction, which may vary in form from single meetings to agricultural courses of two to three days' duration, constitutes the largest means of direct instruction. During the year ended April 30, 1929, 265 meetings were held with a total attendance of 23,562 persons. The Extension Department advertises the fact that lectures on certain definite subjects are available and applications for these lectures are submitted by community organizations, each applicant stating the preference of the community as to subject. The date allotted to each district is chosen by the Department in order that lecture circuits which provide for economy of time and expense may be arranged, and posters to assist in advertising

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are supplied to the community organization. Generally speaking the community is expected to assume responsibility for the advertising and for hall accommodation, the University providing the instruction entirely free of cost.

Study has been applied to many factors which enter into the question of extra-mural lecture service. Instruction has ranged from a single meeting to a course of three days' duration with meetings from once to three times per day. Variation in program from instruction on a single definite subject to a course on general agriculture has been tried. The best time of meeting has come under survey, whether morning, afternoon or evening. Lantern slides, moving pictures and charts have been used and their effectiveness noted, and although the results of observation and study cannot be calculated on an exact basis, the following conclusions have been reached:

1. The single meeting is the most successful.
2. One subject only, generally speaking, should be dealt with at any one meeting.
3. The afternoon is the best time for meetings.
4. Lantern slides are effective for illustration purposes, but are not used generally owing largely to a lack of proper electric light services at the majority of places.
5. Motion pictures are not favored for definite educational meetings. They are desirable for evening gatherings which take on the nature of community rallies and are attended by men, women, and children. Their high initial cost, the fact that they quickly become out-of-date and have to be replaced, and also that they give the personality of the speaker little scope and tend to hinder discussion are important reasons for not using motion pictures generally.
6. Charts are valuable for any type of meeting. Demonstration material is invariably useful, but it is not used extensively owing to the difficulty of carrying a sufficient supply.
7. Large attendances do not always indicate success. The difficulty of inducing free discussion—so important a factor when dealing with an adult audience—increases with the size of the audience.

Railway coaches have been used several times as travelling classrooms and invariably with success. Some appeal attaches to the railway coach which seems to be a guarantee of satisfactory attendance which cannot always be claimed for meetings held in the community hall or school house. Furthermore, the railway coach permits the carrying of ample demonstration material which aids greatly in giving satisfactory instruction. The railway companies have readily and generously coöperated whenever this method has been used.

Lectures by radio, at regular intervals, are given during the winter months on timely agricultural topics. For this service the regular members of the College staff are used almost entirely. During the winter of 1928-29, the lectures, each of about twenty minutes' duration, were given through Station C.K.C.K., which is situated at Regina. For this purpose special amplifying equipment was installed in the College building and the broad-

casting done by remote control. This method of transmission proved entirely satisfactory. The lectures have been given in some cases as a miscellaneous series and at other times as a series on one subject in the nature of a short course. Sufficient data, however, have not been secured on which to base a comparison of the effectiveness of the two methods.

The type of lecturer employed is a matter of paramount importance and hence the utmost care must be exercized in choosing the lecture staff. Generally speaking, it is true that the college-trained man who has also farmed successfully is the most effective teacher of adult farmers. As a result, those employed for this work, in so far as they can be secured, are graduates of agricultural colleges who are actually farming successfully and who have the time during the winter months to engage in extension services. The matter is even carried a step further and men are chosen who have made a specialty of some one branch of agriculture. As an example, the lecturer on gardening and other horticultural topics this year was a man who has made horticulture his specialty and life-long hobby and is thus exceptionally well qualified to speak on the subject.

The staff of the Agricultural College is used as fully as possible, the experience being that the visits of these men are invariably highly appreciated by the rural communities. Moreover, such visits also assist the members of the staff to keep in touch with rural problems.

In addition to the lecture service, the demonstration method of instruction is used extensively and is invariably effective. An outstanding example is the demonstration of plows and plowing which has become very popular in recent years. The plowing demonstration is taking the place of the plowing match. The farmers bring their teams and ordinary plow outfits to a central point in the community and the expert from the College checks each plow in turn, making such adjustments as are necessary and endeavouring to show the effect on the plow and on the quality of the plowing. The draft of each plow is measured with a dynamometer and in many instances better adjustments result in lighter draft, thus reducing the power requirement. The on-lookers follow the plow down the field, noting the changes and the results. A short talk to clinch the results of observation is usually given on the general principles of plow operation and tillage practice.

In dealing with poultry subjects, methods of culling, killing, plucking, dressing and packing are demonstrated; in horticulture, the pruning of fruit trees is demonstrated. Other examples might be quoted but the foregoing will suffice.

Another method of demonstrating successful farm practices is that of organizing what are sometimes known as field days within the community. Visits are made to farms where features of special interest can be observed. It may be a field of sweet clover or corn, or a shelter belt or a well-arranged farm garden, or an outstanding group of livestock. A specialist from the University is usually on hand to assist in driving home the lessons. But the great value of these visits lies in the fact that the things have actually been seen on a farm in one's own neighborhood and no further evidence of their value should be required.

Another practice which is encouraged is the organizing of community excursions to such places as the Dominion Experimental Farms, the Forest Nursery Stations, the University, or any other points of particular interest. Parties visiting the University are encouraged to arrive about noon. Free lunch is provided by the University, after which visits are made to the experimental fields, gardens, live stock barns, the poultry plant and to other places of interest. The staff of each Department is ready to assist such parties by acting as guides and by giving talks or demonstrations when required.

As a supplement to services which promote direct contact between the College representative and the farmer, a fairly complete list of bulletins and circulars is available and can be secured upon application. The topics covered include most important farm subjects. The bulletins are issued in what is known as the Agricultural Extension Series which series now includes 44 publications. In addition to the printed bulletins some of the College Departments have for distribution a number of stencilled circulars, each of which deals with a specific problem. Members of the staff also occasionally contribute articles on timely questions to agricultural journals.

A further definite means of giving information is by the answering of questions received by letter from farmers about farm problems. Each of the College Departments receives and answers a large number of letters, the total running into many thousands annually. Writing direct to the College is encouraged and the answering of such letters is looked upon as a very effective means of giving service to the farmer.

In addition to the methods already described, there are many other opportunities for contact with those in the rural communities. There are the various field crop competitions which entail a visit by a representative of the University to the farm of each competitor; there are the local seed and poultry shows, the Provincial seed fair, the display exhibits at the Provincial exhibitions and various conventions and conferences. The work of the judges at exhibitions is considered to be a valuable means of instruction in agricultural standards. To make this work as reliable as possible, all judges attend an annual conference and short course at the University immediately prior to the exhibition season, the particular object being to bring about uniformity in the standards of judging.

There is a very evident weakness in this program, which in a measure applies to most adult instruction, namely, that it often fails to reach those who need it most. The indifferent farmer rarely attends agricultural meetings, seldom exhibits at fairs, may not subscribe to any agricultural journal, probably lacks faith in his Agricultural College, and is often critical of the information he does receive. Such a man can be reached to the greatest advantage through the example of his neighbour. If the successful neighbour secures a new variety of grain or adopts a more up-to-date practice or secures a more efficient machine, the indifferent farmer across the road soon learns of it and is shrewd enough to profit by it. It is the man who is difficult to reach who makes necessary such a variety of extension services, all of which aim at the same goal, namely better farming.

It is fully realized that the success of this program of instruction depends vitally on the rural communities having confidence in the services of the University. A consistent endeavour is made, therefore, to have it become generally understood that the University of Saskatchewan is a state institution, its services being designed and intended for all citizens of the province, and the utmost attention is given to offering services which meet a definite need and which are of such calibre as to command general approval.

General Conclusions

Experience forces the conclusion that, generally speaking, adults will not invest much time or money in securing information. This means that, owing to the cost involved, the numbers of persons who will attend intramural courses will remain an exceedingly small percentage of the total reached. As previously stated, the big problem is to carry the college to the country and make information so accessible as to be easily within reach of all. In implementing such a program, the wisdom of using the local community organization as the medium has become clearly established. It fosters self-help and responsibility by giving the organization a definite part in making the University services available.

The following points are stated in conclusion as being of more than ordinary importance in carrying instruction to the rural communities:—

1. The demand for and effectiveness of work in the rural communities fluctuates inversely with the general prosperity of the times. When the farmers generally are flourishing, the attitude toward agricultural educational services becomes lukewarm, but in times of economic stress, the demand for information and for remedies for difficulties becomes keen. This fact must be taken advantage of.
2. Educational activities, meetings particularly, must be carried on only during the slack farm seasons.
3. The afternoon is much the best time of day for meetings.
4. One subject only should be discussed at any one meeting.
5. Demonstration material augments the effectiveness of meetings and discussions and should be used wherever convenient.
6. The information given must be exceedingly practical and capable of being easily put into practice by the farmer.
7. Finally, the most meticulous care must be exercised in the selection of the lecture staff in order that the farmers may have confidence in the information given and in the services of the University as a whole.

LA TOXICITE DE CERTAINES MATIERES FERTILISANTES. SON UTILISATION AGRICOLE*

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La toxicité et ses caractères importants: On sait depuis longtemps en agriculture que certains engrais, le crud ammoniac et la cyanamide calcique notamment, peuvent exercer, au moment où on les applique, une action toxique sur les plantes.

Cette toxicité peut être inhérente au produit lui-même, ou dépendre d'une proportion faible et variable de composés hautement toxiques, tels que les sulfocyanures de certains cruds, ou quelques dérivés cyanés dans les produits à base de cyanamide. On a également reconnu la nécessité de faire subir au nitrate de soude un contrôle chimique sévère pour s'assurer de l'absence, sinon absolue au moins pratiquement complète de perchlorates, chlorates et périodates, de vérifier attentivement la purification des sels potassiques de lacs salés en raison de leur teneur en borax.

La toxicité peut être pratiquement *permanente* ne s'atténuant qu'à la longue par dilution ou entraînement par les eaux. Elle peut être temporaire et s'éliminer plus ou moins rapidement au contact du sol par le jeu des actions chimiques: oxydations et réductions, neutralisations, précipitations, ou par des actions microbiennes dont l'une des plus intéressantes est la destruction des composés phénoliques.

Il va de soi que l'empoisonnement est sous la dépendance de la concentration, que très dilués les toxiques peuvent exercer une action favorable, et qu'inversement, trop concentrés, les sels nutritifs les meilleurs peuvent tuer les végétaux.

Mécanisme de la toxicité: Sans entrer dans de grands détails sur le mécanisme intime de la toxicité, il est indispensable de rappeler que très souvent la mort résulte de l'arrêt ou de troubles graves d'une fonction biologique essentielle.

La destruction de matière par voie chimique n'est pas indispensable et, fréquemment, l'action nocive se ramène à une plasmolyse, à une déshydratation de cellules superficielles.

Résistance des plantes: La résistance des plantes aux substances toxiques est très inégale suivant l'espèce, la variété, l'âge. Ainsi les jeunes plantules, dans la période qui suit la germination, sont particulièrement sensibles à toute espèce de toxicité et c'est la raison pour laquelle il est possible d'appliquer en couverture, sur les cultures bien développées, des quantités de certaines matières comme les nitrates, les sels potassiques, qui se montrent alors très avantageux, tandis que si on les avait appliqués au moment des semailles, ou aussitôt après la levée, on aurait obtenu des résultats lamentables.

Les caractères physiques des végétaux n'ont pas moins d'importance. A cet égard le port des feuilles presque horizontal ou au contraire dressé, le fait que les organes aériens sont plus ou moins velus ou au contraire parfaitement lisses, l'existence d'un épiderme mince et facilement mouillé, ou au

*Communication au 7ème Congrès de Chimie Industrielle, Paris.

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contraire d'une cuticule épaisse ou difficilement mouillée par l'eau en raison d'une sorte d'enduit cireux, constituent les raisons les plus apparentes et bien reconnues à présent du fait que le même traitement attaque gravement certaines plantes sans nuire aux autres dans la même culture.

De nombreuses observations tendent également à prouver qu'une même plante présente, dans le cours de son développement, une aptitude inégale à être mouillée par une solution donnée. Ce caractère s'ajoute à la considération de phases particulièrement délicates dans le cours du développement de la plante; on peut citer notamment la grande sensibilité des fleurs des cucurbitacées aux agents chimiques qui contraste singulièrement avec la rugosité et la grossièreté de leur feuillage.

Les considérations d'ordre chimique sont donc fréquemment insuffisantes pour comprendre le mécanisme de ces actions sélectives, et c'est souvent dans la morphologie des plantes et dans le processus physique de l'action qu'on peut en trouver la cause.

Préparations inégalement mouillantes et adhérentes: Il est clair que si une gouttelette de solution toxique s'attache fortement à une feuille, s'y étale, elle produira le maximum d'action, tandis, qu'au contraire, une même gouttelette gardant la forme sphéroïdale, roulant en quelque sorte à la surface du végétal, tombe sur le sol au moindre coup de vent et n'a, en fait, exercé aucune action nuisible. Nous touchons, d'ailleurs, ici, à un caractère essentiel pour toutes les préparations chimiques employées dans les traitements des plantes lorsqu'il s'agit de lutter contre leurs maladies ou contre leurs parasites.

Dans les régions viticoles on attache avec raison la plus grande importance à la possibilité de rendre les bouillies cupriques mouillantes, adhérentes; ceci est surtout affaire de tension superficielle.

Résultats pratiques déjà obtenus: La connaissance déjà avancée des actions nocives dont nous nous occupons aujourd'hui permet d'obtenir un résultat extrêmement intéressant puisqu'il est possible, au moyen d'une application générale sur une population végétale mélangée, de détruire certaines plantes tout en respectant complètement celles qu'on désire garder. Rappelons ici la destruction des sanves et d'un certain nombre d'autres mauvaises herbes dans les champs de céréales au moyen de l'acide sulfurique suivant la méthode de M. Rabaté. Rappelons aussi l'emploi de dissolutions de sylvinite, ou de sylvinite finement moulue, pour obtenir le même résultat dans les céréales ou dans les betteraves.

Cette sylvinite, en poudre fine, appliquée à la rosée du matin à raison de 800 à 1000 kilos à l'hectare sur une céréale envahie de sanves, de ravenelles, de vesces sauvages, donne des résultats surprenants, détruisant la plupart des espèces parasites et augmentant au contraire la vigueur de l'avoine ou du blé.

Mentionnons encore l'emploi de sulfate de cuivre permettant d'obtenir la destruction des mauvaises herbes dans les champs de pommes de terre. Signalons enfin l'emploi de mélanges complexes renfermant à la fois un composé toxique, chlorate ou perchlorate par exemple, ou sel de cuivre, associé à une matière fertilisante. Le but visé dans l'emploi de ces formules est d'obtenir d'abord une action de destruction sélective, suivie bientôt d'une action fertilisante favorable aux plantes conservées.

Utilisation industrielle de la toxicité: Les caractéristiques de la toxicité une fois connues, il devient possible, non seulement d'en éviter les inconvénients, mais même de s'arranger pour en tirer avantage; l'action toxique est utilisable contre les parasites de tous ordres, microbiens, végétaux ou animaux.

Il est d'ailleurs à noter que les industries microbiologiques savent fort bien, depuis de longues années, utiliser l'action de composés, tels que les fluorures (en distillerie) ou l'acide sulfureux (en oenologie) pour exercer une action sélective fort utile dans les fermentations.

Dans certains cas il est économique d'empoisonner de façon permanente des plantes qui poussent spontanément; c'est le cas des avenues, des allées de parcs et de jardins. L'emploi raisonné des composés chimiques permet d'économiser de la main d'oeuvre et de maintenir ces surfaces pendant plusieurs mois dans l'état de propreté voulu sans qu'il soit besoin de les ratisser. Pour ces applications on doit rechercher dans l'arsenal de la chimie, soit des substances dont la toxicité est énergique et permanente, telles que les chlorates, soit des substances relativement peu toxiques mais de prix faible, telles que le chlorure de sodium ou le chlorure de calcium résiduels.

Malgré tout, les applications que nous venons d'indiquer intéressent beaucoup moins l'agriculture proprement dite que les villes et les industries.

Utilisation agricole de la toxicité—résultats nouveaux acquis: Nous avons indiqué déjà comme bien entrée dans la pratique, l'action sélective de quelques traitements chimiques détruisant les mauvaises herbes dans les céréales, les betteraves, les pommes de terre. L'emploi du crud ammoniac est fait plus d'un mois avant les semailles ou le réveil de la végétation, généralement pour éviter l'effet de toxicité éventuel, mais dans quelques cas aussi pour obtenir d'abord un effet de stérilisation partielle et de nettoyage du sol.

Un agriculteur avisé de la Somme nous a affirmé obtenir une levée de lin propre dans des terres envahies de renoncules en appliquant la fumure azotée nécessaire sous forme de crud ammoniac une dizaine de jours seulement avant les semailles, sachant fort bien, disait-il, qu'une pareille manière de procéder aurait présenté le plus grand danger pour la germination s'il s'était agi de semailles de blé. Certainement une telle pratique reste aléatoire en raison des différences considérables de composition pouvant exister entre deux cruds de même teneur en azote. Mais l'indication nous a paru digne d'être retenue dans le sens d'une possibilité pratique, plus largement utilisable moyennant une étude suffisante.

M. Leveque, Directeur des S. A. de la Sarthe a obtenu par une application de 1800 kilos de crud à l'ha. la destruction de l'avoine à chapelet et du chiendent, avec retour d'une bonne fertilité quatre mois après.

Dans le Nord, l'application des fortes doses de sylvinite sur terres de limon, dès la moisson des céréales, lors du déchaumage, contribue d'abord au nettoyage du sol. Cette pratique donne, par surcroît, la certitude d'éviter après labour tout inconvénient chimique ou physique de l'engrais, et d'assurer sa parfaite répartition.

Des rapports récents nous ont fait connaître la possibilité de détruire par des applications locales lourdes, la cuscute dans les champs de luzerne; peu de mois après la légumineuse y trouve le double avantage du nettoyage et de la fumure.

Les fortes doses de sylvinite mettent les herbages à l'abri des déprédations du ver blanc du hanneton. Le ver fil de fer du taupin résiste mal à ces applications.

Sans que la technique en soit encore précisée, les solutions très concentrées de sylvinite appliquées en traitements d'hiver aux écorces des arbres fruitiers combattent les parasites et les microörganismes pathogènes.

Dans ces derniers exemples, la toxicité de fortes concentrations s'élimine par simple dilution. Il n'est donc pas téméraire de prévoir l'extension des pratiques culturales basées sur une toxicité non permanente, suivie automatiquement de l'action fertilisante de la matière employée.

Mentionnons, en outre des actions apparentes, un effet certain de stérilisation partielle, modifiant la population de microörganismes du sol. Au lieu de l'obtenir par des substances à proprement parler antiseptiques, ne vaut-il pas mieux la réaliser grâce à une propriété accessoire des engrais?

Utilisation agricole—Progrès à réaliser: Les résultats obtenus sont donc très encourageants, et permettent d'envisager avec une certaine confiance le problème récemment posé par M. Schribaux, du nettoyage chimique des jachères. Il suffit d'obtenir à prix raisonnable des produits de toxicité très élevée mais temporaire, donnant, si possible, naissance à des produits ultimes doués d'action fertilisante, ce qui n'est pas non plus chimérique.

L'augmentation du coût de la main d'oeuvre, l'impuissance des machines à réaliser un nettoyage parfait, même avec les semis en ligne, posent la question sur la base économique, et la possibilité de faire d'une pierre deux coups, nettoyage et fertilisation, y a son importance

Les processus de l'action sélective dont nous avons parlé par les traitements de solutions ou de poudres fines projetées à la rosée du matin comporte le groupement d'observations classant les végétaux d'après leur résistance relative, compte tenu de leur état et des conditions météorologiques. La limite pratique entre les plantes atteintes et les plantes indemnes pourra sans doute être décalée, non seulement en modifiant les concentrations, mais sans doute aussi en faisant varier, par des additions convenables, la tension superficielle des solutions employées.

Nous serons reconnaissants à tous ceux de nos collègues qui voudront bien nous faire connaître des faits précis dans cet ordre d'idées.

Resume

Il est bien connu dans la pratique agricole que certaines matières fertilisantes exercent, au moment de leur application, une action toxique plus ou moins marquée. Dans certains cas ceci constitue un inconvénient, mais il est possible d'exploiter avec avantage la propriété dont il s'agit.

La toxicité peut être permanente ou temporaire. Dans le second cas, il est possible que l'action toxique fasse place à une action fertilisante.

On utilise déjà largement la possibilité d'obtenir dans une population végétale mélangée la destruction de certaines espèces et le renforcement des espèces indemnes.

Une étude plus approfondie permet de réaliser, notamment avec le crud ammoniac ou les sels potassiques, le nettoyage des terres, tout en les fertilisant, et, faisant d'une pierre deux coups, d'arriver à des résultats économiquement remarquables.

Dejeuners Hebdomadaires de la C.S.T.A.

Le 16 novembre les sections de Montréal et de Macdonald se sont réunies sous la présidence de M. April au cours d'un déjeuner en l'honneur du Président Sackville, de passage à Montréal. Après le déjeuner, plusieurs membres appartenant aux deux sections ont décidé de se réunir à nouveau toutes les semaines à un déjeuner de la C.S.T.A. qui se tiendra tous les mercredis à midi et demie au Krausman Lorraine Café, Phillips Square, Montréal. Le but de ces déjeuners, qui n'auront rien d'officiel, est avant tout de donner à tous les membres de la C.S.T.A., quelle que soit la section à laquelle ils appartiennent, une occasion de retrouver d'autres membres de la C.S.T.A. et de resserrer les liens de camaraderie qui unissent tous les membres de notre association.

Les organisateurs désirent insister sur le fait que dans leur pensée ces déjeuners ne sont pas une affaire locale particulière aux sections de Montréal et de Macdonald. Ils espèrent bien y voir les membres de toutes les autres sections lorsqu'ils seront de passage à Montréal le mercredi. En fait, ils espèrent même que les membres des autres sections devant venir à Montréal pour une raison ou une autre choisiront de préference le mercredi, chaque fois que cela leur sera possible, afin de venir assister au déjeuner de la C.S.T.A. Il y aura toujours suffisamment de membres de langue française comme de langue anglaise pour que les membres de toutes les sections et de toutes les provinces s'y sentent parfaitement à l'aise et même en famille.

Par conséquent, à tous un cordial rendez-vous est donné pour midi et demie tous les mercredis chez Krausman.

Fete en L'Honneur de M. Lauziere

Notre confrère M. Henri Lauzière, qui était agronome du Comté d'Arthabaska dans la Province de Québec, vient d'être nommé Inspecteur du District No. 4 en remplacement de M. L. C. Roy qui est entré au service des Chemins de fer Canadiens Nationaux. Nous félicitons bien vivement nos deux confrères des changements qui les concernent respectivement.

Le départ de M. Lauzière a été marqué par une fête donnée en son honneur le 17 novembre à Victoriaville par les cultivateurs du Comté d'Arthabaska. Plusieurs personnalités marquantes et bon nombre de membres de la C.S.T.A. s'étaient à cette occasion rendus à Victoriaville pour manifester leurs sentiments d'amitié envers M. Lauzière. La fête fut un beau succès pour celui-ci, et la reconnaissance exprimée par les cultivateurs du travail effectué par leur agronome fit aussi rejaillir un peu de gloire sur le travail de tous les techniciens agricoles dont ainsi ce fut aussi un peu la fête.

BOOK REVIEWS

A Bibliographical Monograph on Plant Genetics. By H. Matsuura. Published by Tokyo Imperial University (American agent, Fiedler, New York.)

It would be difficult to imagine a more useful publication for the plant geneticist than a complete list of the published papers together with brief statements of the results reported in each. Professor Matsuura has undertaken the enormous labor of making such a compilation and the present volume covers the literature from the beginning of the Mendelian period to 1925. Naturally the usefulness of such a bibliography increases with the user's confidence in its completeness. Unfortunately the author says in the preface "The list does not pretend to be complete".

In Part I (317 large pages) the different plants which have been investigated are treated in alphabetical order and in connection with each a statement is made of the results reported by the various investigators. Owing to the immense range of the work it is obvious that the treatment of each point must be very brief and that there can be no critical discussion. Part II is a list of the papers in plant genetics published from 1900 to 1925, arranged by years and for each year in the alphabetical order of their authors' names. Each title is accompanied by a brief comment usually of 2 or 3 lines. There are convenient indexes of subjects, authors, and species.

Professor Matsuura's labor will greatly reduce that of each of his fellow geneticists. They will look forward to the appearance of the promised second volume which is to cover the publications from 1925 to the present.—W. P. T.

Microbiology. By Benjamin Franklin Lutman. (McGraw-Hill Book Company, Inc., New York, 1929. Pp. 495, fig. 211. Price $4.00)

In contrast to the condition prevailing a decade or two ago when the great majority of books treating of bacteriology and microbiology were written from the medical standpoint, with comparatively little emphasis on the science of bacteriology considered as a whole, the last few years have seen the appearance of a number of works on microbiology in which attempts have been made to give appropriate emphasis to all sides of this ever widening branch of science.

The author of the present work appears to have been particularly successful in producing a well written and well balanced treatment of the subject of general microbiology, and in its conception has departed from the plan usually following in works of this type. As stated in the preface, the general scheme of presentation has been to describe "types" in considerable detail, a scheme which in the reviewer's opinion has been eminently successful, due in no small measure to a very fortunate selection of organisms for type study.

A notable feature of the book is the prominence given to microörganisms other than bacteria proper. Fungi, yeasts and actinomyces are considered at much more length than is usually the case in works on general microbiology, and of the 44 chapters in the book, 10 of these treat of these organisms or their activities.

A detailed description of the chapter titles is out of place. One cannot be otherwise than favorably impressed by the "progressive" arrangement adopted by the author. The earlier chapters treat of general and well established facts to give the student a foothold. Then come the chapters on "types", followed by chapters on microbiology as applied to agriculture, industry and pathology. The final chapters place before the readers in very able manner some of the problems and controversies raging in the field of microbiology, and the fact that three of these are devoted to a discussion of modern attacks on the constancy of species reveals to what extent the author is aware of the importance of present day research which is already working far-reaching changes in our conception of bacteria and bacterial species. A critical chapter dealing with the perplexing problem of classification completes the volume.

Mention should be made of the valuable literature references at the close of each chapter and of the excellent selection of illustrations, over 200 in number, which help to complete a very valuable addition to our literature on microbiology. A. G. L.

CONCERNING THE C.S.T.A.

The 1930 Convention

Owing to an extensive building programme which is now under way at the Ontario Agricultural College, and will continue during 1930, it has been considered desirable not to hold the next convention of the C.S.T.A. at that institution as formerly agreed upon, but to transfer it to some other point in eastern Canada.

At a meeting of the Board of Directors held at Toronto on November 23rd, an invitation from the Maritime provinces was accepted. The Society has never held an annual meeting in any of the three most eastern provinces, but has met in each of the other six provinces.

The 1930 convention will therefore be held at Wolfville, N.S., the seat of Acadia University. The tentative dates are the week of June 23rd, with three days devoted to business sessions, lectures, group meetings, etc., and three days to a motor tour of the three provinces.

Further announcements regarding the convention programme will appear in these pages from time to time.

Weekly Luncheons at Montreal

A group of C.S.T.A. members resident in Montreal have decided to hold a weekly luncheon, every Wednesday at 12.30 p.m., at Krausman's Lorraine Café, Phillips Square. The opening luncheon will be held on Wednesday, December 4th. There is to be nothing formal in the way of a programme, the object being to bring about closer acquaintance between members and a more intimate knowledge of the professional activities of each member.

The group which has organized these weekly luncheons desires to assure every member of the Society that a cordial welcome awaits him at Krausman's every Wednesday, and to urge members, when planning to

visit Montreal, to keep these luncheons in mind. A further announcement appears in the French section of this issue.

Employment Bureau

For a number of years—almost since the organization of the Society—consideration has been given to the possibility of operating a Bureau of Records and Employment at the central office of the C.S.T.A. A great deal of preliminary work has been done, particularly in the compilation of members' records and this work has resulted in the publication of an annual list of members and a complete "Who's Who" in 1924 and 1929. The central office now has complete records of the biography, academic training and professional experience of practically all of the 1,100 members of the Society, together with a classification of each member's particular interests in the various branches of agriculture.

With this information at hand, it is considered that something might be done to develop an Employment Bureau which would serve as a clearing house between (1) institutions, governments and commercial firms seeking technically trained men and (2) members of the Society seeking employment or advancement.

The Directors of the C.S.T.A. recently decided that an Employment Bureau should be started, and, as an initial step it is intended to advertise in the journal all vacancies in professional agriculture that are brought to the notice of the Society. Such advertisements will carry key numbers, together wth the qualifications required for each position and the salary offered. Applicants will refer direct to the Society and these communications will be forwarded in turn, to the advertiser.

Immediate steps are being taken to advise employing institutions of the action taken by the Directors and to urge their co-operation in making the venture a useful one. Without such co-operation it is obviously impracticable.

Abstracts of Canadian Literature

A great deal of scientific work, dealing with the various branches of agriculture is being done by Canadians. Some of the results are published in *Scientific Agriculture,* but a great many appear elsewhere, as bulletins, or as articles in other journals. In order that members of the C.S.T.A. may be kept informed regarding such material, it is proposed that a section of *Scientific Agriculture* be devoted to abstracts of scientific literature prepared by Canadian authors. Each abstract would give the title of the paper, the name of the author, the source of publicaton and a brief statement of the context. The entire field of agricultural science has been divided into 17 sections and, as soon as suitable abstractors have been found, who are willing to give their assistance, this new section of the journal will be introduced.

Directors' Meeting

A special meeting of the Board of Directors of the C.S.T.A. was held at the King Edward Hotel, Toronto, on Saturday November 23rd. Nine Directors, together with the General Secretary and the French Secretary, were in attendance.

Notes and News

Professor J. P. Sackville, President of the Society, addressed meetings of local branches at Amherst, N.S., on November 13th, Quebec, P.Q., on November 15th, and Montreal, P.Q., and Ottawa, Ont., on November 16th. All meetings were very successful, the total attendance at the four meetings being approximately 200.

G. G. Moe (McGill '14), Associate Professor of Agronomy at the University of British Columbia since 1922, has been advanced to the status of Professor and Head of the Department.

Ernest Rhoades (McGill '12), Editor in the Publications Branch of the Dominion Department of Agriculture, has been appointed Secretary of the World's Grain Exhibition and Conference which will be held at Regina, Sask., in 1932.

L. S. McLaine (Boston '10), Chief, Division of Foreign Pests' Suppression of the Dominion Entomological Branch, is President of the Professional Institute of the Civil Service for the year 1930.

W. A. Maw (McGill '20), Assistant Professor of Poultry Husbandry at Macdonald College, P.Q., has been elected Chairman of the programme committee for the Canadian Section of the Fourth World's Poultry Congress to be held in London, England, in July, 1930.

C. M. Meek (Toronto '22) has accepted a position as Fieldman with the Ottawa Dairy Company, Ltd., at Ottawa. His mailing address is 211 Carling Avenue, Ottawa, Ont.

Erdman Braun (Manitoba '28) is taking graduate work at the University of Minnesota. Until July 1st, 1930, his address will be: Bee Division, University Farm, St. Paul, Minn.

H. D. Mitchell (McGill '15) has joined the staff of Jamesway Limited, 505 Talbot Street, London, Ont.

M. H. Hudon (Laval '25) has received the appointment of Chief Technical Adviser to the Chateau Cheese Co., Ltd., 12 York Street, Ottawa, Ont.

C. A. Tregillus (Toronto '13) has changed his address to Mill Road Farm, Everett, Ill. U.S.A.

E. A. Howrie (Saskatchewan '23), formerly Principal at Eskbank High School, is now Principal of Hatton High School. His mailing address is Box 24, Hatton, Sask.

A. R. G. Emslie (Toronto '28) has changed his address for the winter months. He is at 666 Spadina Avenue, Toronto 4, Ont.

Antonio Besner (Montreal '23), formerly Assistant County Agriculturist in Matane County, P.Q., has been transferred to Ste. Anne des Monts, Gaspé County, P.Q.

C. A. Zavitz (Toronto '88) has left for Florida to spend the winter months. His address is Apartment 5, Court Park, Second Avenue West, St. Petersburg, Florida.

W. F. Jones (Toronto '23), recently appointed General Manager of the Ottawa Dairy Co., Ltd., has been elected a member of the Board of Directors of Cornwall Dairy Products Ltd.

N. A. Patterson (McGill '27), Junior Entomologist under the Dominion Entomological Branch at Annapolis Royal, N.S., is taking graduate work at Macdonald College, P.Q.

Cecil Yarwood (British Columbia '29) is taking graduate work in the Botany Division, Purdue University, Lafayette, Ind.

H. L. Trueman (Toronto '21) and C. Eric Boulden (McGill '18) have been awarded gold medals and certificates of award by the National Association of Agronomy in recognition of the best reports on soil improvement campaigns carried on in their respective provinces, i.e. Ontario and Nova Scotia.

J. A. Martin (Montreal '28) is taking graduate work in form management at Cornell University. His mailing address is 185 Oxford Place, Ithaca, N.Y.

Applications for Membership

The following applications for regular membership have been received since November 1, 1929:—

Asher, C. R. (British Columbia, 1928, B.S.A.) Vancouver, B.C.

Colson, H. J. (Toronto, 1929, B.S.A.) Toronto, Ont.

Cunningham, J. R. (Toronto, 1915, B.V.Sc.) Summerside, P.E.I.

Dupuis, Auguste (Laval, 1907, B.S.,B.L.L.) Ste. Anne de la Pocatière, P.Q.

Ethier, Gaston (Montreal, 1929, B.S.A.) Ste. Anne de la Pocatière, P.Q.

Godel, G. L. (Saskatchewan, 1929, B.S.A.) Saskatoon, Sask.

Hawkes, Miss M. E. (McGill, 1929, B.S.A.) Montreal, P.Q.

Hutchison, L. J. (Saskatchewan, 1927, B.S.A.) Regina, Sask.

Jackson, F. W. (Rutgers, 1920, B.Sc.) New York City, U.S.A.

Larson, H. W. E. (Oregon State College, 1928, M.S.) Saskatoon, Sask.

Moss, H. C. (Saskatchewan, 1924, B.S.A.) Saskatoon, Sask.

Murchie, R. W. (Glasgow, 1906, M.A., Minnesota, 1927, Ph.D.) Winnipeg, Man.

McLeod, W. J. (Saskatchewan, 1923, B.S.A.) Govan, Sask.

McMullen, W. S. (Toronto, 1922, B.S.A.) Waterloo, Ont.

Robinson, D. R. (Saskatchewan, 1928, B.S.A.) Saskatoon, Sask.

Sprenkle, P. H. (Pennsylvania State College, 1918, B.S.A.) Montreal, P.Q.

Swanson, J. R. (British Columbia, 1929, B.S.A.) New Westminster, B.C.

Yarwood, Cecil (British Columbia, 1929, B.S.A.) Lafayette, Ind. U.S.A.

Vacancies in Dominion Department of Agriculture

The Civil Service Commission at Ottawa is advertising the following vacancies in the Dominion Department of Agriculture. Applications should be addressed to the Secretary of the Commission:

Poultry Inspector (Temporary). Initial Salary $1,620 per annum up to a maximum salary of $1,920. To be located in the Prairie Provinces. Applications must be filed not later than December 10, 1929.

Entomologist. Initial salary $2,520 per annum up to a maximum salary of $2,880 per annum. To be located at Fredericton, N.B. Applications must be filed not later than December 12, 1929.

District Supervisor of Beef Grading. Initial salary $2,520 per annum up to a maximum of $3,000 per annum. Applications must be filed not later than December 19, 1929.

Student Members

Following is a list of those students, completing the degree course in agriculture at the various Canadian universities and agricultural colleges, who have joined the C.S.T.A. as student members:—

Macdonald College, P.Q.

Cameron, J. M.
Hudson, S. C.
Johnson, R. E.
Longley, R. P.
Munro, S. S.
MacVicar, R. M.
McLeod, F. C.
Parris, G. K.
Woodward, J. C.

Manitoba Agricultural College, Winnipeg, Man.

Bergsteinsson, H. N.
Cormack, M. W.
Edgecombe, S. W.
Gniazdoski, F. J.
Hadley, S. T.
Handford, R. H.
Isa, J. M.
McLean, D. M.
Patterson, H. L.
Peterson, R. F.
Pickersgill, T. B.
Poole, J.
Rowland, M. H.

University of Saskatchewan, Saskatoon, Sask.

Chepil, W. S.

University of Alberta, Edmonton, Alta.

Campbell, H. L.
Charnetski, A. J.
Fawcett, G. G.
Grant, R. A.
Hide, J. C.
Jellis, W. H.
Lehane, J.
Milligan, R. J.
Obee, C. G.

Membership

Now that the C.S.T.A. is approaching the tenth anniversary of its organization in June, 1920, it is interesting to study the growth in membership which has taken place. The stability of membership in any organization may be accepted as an indication of its usefulness and, in the case of the C.S.T.A., there has been a steady growth. In no year has the total membership been less than in the previous year. It should also be emphasized that the payment of fees is enforced rigidly and that no member is retained on the active list who is more than twelve months in arrears.

The following table shows the membership of the C.S.T.A. each year since 1920:—

	Regular Members	Student Members*	Total
June, 1920	417†	—	417
" 1921	557	—	557
" 1922	583	—	583
" 1923	662	—	662
" 1924	734	—	734
" 1925	747	—	747
" 1926	868	43	911
" 1927	987	13	1,000
" 1928	989	34	1,023
" 1929	1,048	36	1,084
December 1, 1929	1,085	33	1,118

*Student membership was established during the year 1925-26 and is open to students in the senior year of the degree course at any agricultural college in Canada.
†Charter members.

At the present time a membership campaign is under way, with the object of increasing the total list to 1,200 by May 31, 1930. Members can assist in this campaign by bringing the C.S.T.A. to the attention of non-members and urging them to get in touch with a local secretary or with the central office at Ottawa.

C.S.T.A. Headquarters

Announcement has already been made in these pages (May, 1929, pp. 627-628) of the establishment of adequate headquarters for the Society at Ottawa, the gift of a group of agricultural manufacturers and milling companies. In order that more members may be familiar with these headquarters, and that even more use may be made of them by visitors to Ottawa, a handbook is now being prepared for distribution to the entire membership body. Illustrations of the lounge room and board room will be included, together with an outline of the manner in which this donation was brought about, and the facilities which are available. This handbook will be ready at an early date.